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V.

VI. Heavy-duty Pickups and Vans

A. Introduction and Summary of Phase 1 HD Pickup and Van Standards

In the Phase 1 rule, EPA and NHTSA established GHG and fuel consumption standards and a program structure for complete Class 2b and 3 heavy-duty vehicles (referred to in these rules as "HD pickups and vans"), as described below. The Phase 1 standards began to be phased-in in MY 2014 and the agencies believe the structure of the program is working well. The agencies are proposing to retain ~~many~~most elements from the structure of the program established in the Phase 1 rule for Phase 2 while proposing to require additional GHG reductions and fuel consumption improvements through increasing the stringency of standards for MYs 2021-2025 and later.

Heavy-duty vehicles with GVWR between 8,501 and 10,000 lb are classified in the industry as Class 2b motor vehicles. Class 2b ~~also~~ includes vehicles classified as medium-duty passenger vehicles (MDPVs) ~~that~~such as very large SUVs. Because MDPVs and frequently used like like-duty passenger vehicles, they are regulated by the agencies under the light-duty vehicle rules~~,~~. Thus the agencies did not adopt additional requirements for MDPVs in the Phase 1 rule and are not proposing additional requirements for MDPVs in this rulemaking. Heavy-duty vehicles with GVWR between 10,001 and 14,000 lb are classified as Class 3 motor vehicles. Class 2b and Class 3 heavy-duty vehicles together emit about 15 percent of today's GHG emissions from the heavy-duty vehicle sector.

About 90 percent of HD pickups and vans are ¾-ton and 1-ton pickup trucks, 12- and 15-passenger vans, and large work vans that are sold by vehicle manufacturers as complete vehicles, with no secondary manufacturer making substantial modifications prior to registration and use. ~~These vehicle manufacturers are~~Most of these vehicles are produced by companies with major light-duty markets in the United States, primarily Ford, General Motors, and Chrysler. Often, the technologies available to reduce fuel consumption and GHG emissions from this segment are similar to the technologies used on light-duty pickup trucks and vans, including both engine efficiency improvements (for gasoline and diesel engines) and vehicle efficiency improvements.

~~For these reasons,~~ In the Phase 1 rule EPA adopted GHG standards for HD pickups and vans based on the whole vehicle (including the engine), expressed as grams of CO_2 per mile, consistent with the way these vehicles are regulated by EPA today for criteria pollutants. NHTSA adopted corresponding gallons per 100 mile fuel consumption standards that are likewise based on the whole vehicle. This complete vehicle approach adopted by both agencies for HD pickups and vans was consistent with the recommendations of the NAS Committee in its 2010 Report. EPA and NHTSA adopted a structure for the Phase 1 HD pickup and van standards that ~~paralleled~~ in many respects ~~the previously-established~~paralleled long-standing ~~DOT~~NHTSA CAFE standards and more recent coordinated EPA ~~and NHTSA~~GHG standards for manufacturers' fleets of new light-duty ~~program for control of GHG emissions and improvement of fuel consumption, which also involves vehicle-based standards~~vehicles. These commonalities include a new vehicle fleet average standard for each manufacturer in each model year and the determination of these fleet average standards based on production volume-weighted targets for each model, with the targets varying based on a defined vehicle attribute. Vehicle testing for both the HD and light-duty vehicle programs is conducted on chassis dynamometers using the drive cycles from the EPA Federal Test Procedure (Light-duty FTP or "city" test) and Highway Fuel Economy Test (HFET or "highway" test).[1]

For the light-duty GHG and fuel economy[2] standards, the agencies factored in vehicle size by basing the emissions and fuel economy targets on vehicle footprint (the wheelbase times the average track width).[3] For those standards, passenger cars and light trucks with larger footprints are assigned higher GHG and lower fuel economy target levels in acknowledgement of their inherent tendency to consume more fuel and emit more GHGs per mile. EISA requires that NHTSA study "the appropriate metric for measuring and expressing commercial medium- and heavy-duty vehicle and work truck fuel efficiency performance, taking into consideration, among other things, the work performed by such on-highway vehicles and work trucks…" 49 U.S.C. 32902 (k) (1)(B).[4] For HD pickups and vans, the agencies also set standards based on vehicle attributes, but used a work-based metric as the attribute rather than the footprint attribute utilized in the light-duty vehicle rulemaking. Work-based measures such as payload and towing capability are key among the parameters that characterize differences in the design of these vehicles, as well as differences in how the vehicles will be utilized. Buyers consider these utility-based attributes when purchasing a HD pickup or van. ~~NHTSA is in fact required to study "the appropriate metric for measuring and expressing commercial medium- and heavy-duty vehicle and work truck fuel efficiency performance, taking into consideration, the work~~

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[1] The Light-duty FTP is a vehicle driving cycle that was originally developed for certifying light-duty vehicles and subsequently applied to HD chassis testing for criteria pollutants. This contrasts with the Heavy-duty FTP, which refers to the transient engine test cycles used for certifying heavy-duty engines (with separate cycles specified for diesel and spark-ignition engines).

[2] Light duty fuel *economy* standards are expressed as miles per gallon (mpg), which is inverse to the HD fuel *consumption* standards which are expressed as gallons per 100 miles.

[3] EISA requires CAFE standards for passenger cars and light trucks to be attribute-based; *See* 49 U.S.C. 32902(b)(3)(A).

[4] The NAS 2010 report likewise recommended standards recognizing the work function of HD vehicles. See 76 FR 57161/2.

~~performed by such on-highway vehicles and work trucks…" 49 U.S.C. Section 32902 (k)(1)(B).~~ [5] EPA and NHTSA therefore finalized Phase 1 standards for HD pickups and vans based on a "work factor" attribute that combines the vehicle's payload and towing capabilities, with an added adjustment for 4-wheel drive vehicles. See generally 76 FR 57161-62.

For Phase 1, the agencies adopted provisions such that each manufacturer's fleet average standard is based on production volume-weighting of target standards for all vehicles that in turn are based on each vehicle's work factor. These target standards are taken from a set of curves (mathematical functions). The Phase 1 curves are shown in the figures below for reference and are described in detail in the Phase 1 final rule.[6] The agencies established separate curves for diesel and gasoline HD pickups and vans. The agencies are proposing to continue to use the work-based attribute and gradually declining standards approach for the Phase 2 standards, as discussed in Section VI.B. below. Note that under this approach, manufacturers are not encouraged to reduce the capabilities of these vehicles because less capable vehicles are required to have proportionally lower emissions and fuel consumption.

[5] ~~The NAS 2010 report likewise recommended standards recognizing the work function of HD vehicles. See 76 FR 57161/2.~~

[6] The Phase 1 Final Rule provides a full discussion of the standard curves including the equations and coefficients. See 76 FR 57162-57165, September 15 2011. The standards are also provided in the regulations at 40 CFR 1037.104.

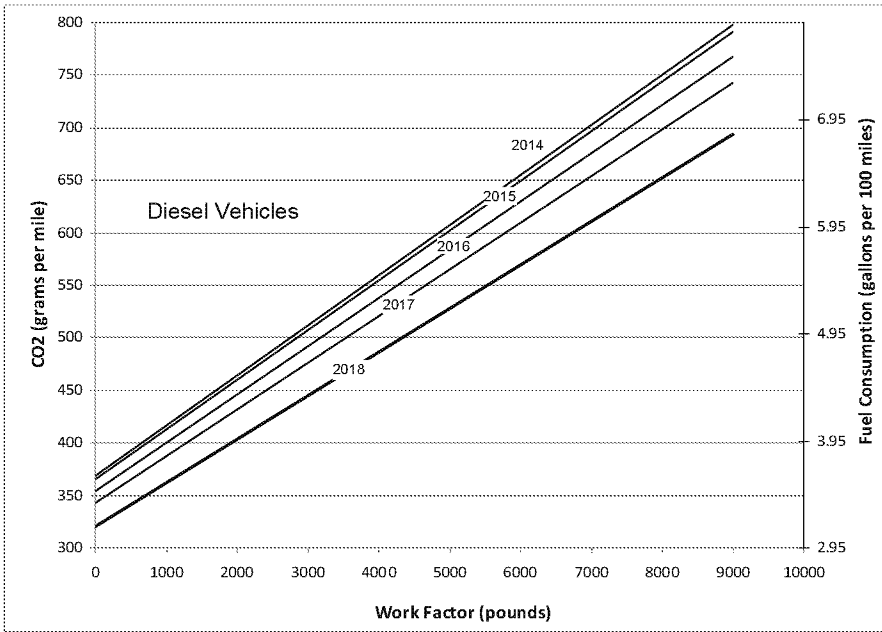


Figure VI-1: EPA Phase 1 CO_2 Target Standards and NHTSA Fuel Consumption Target Standards for Diesel HD Pickups and Vans[7]

[7] The NHTSA program provides voluntary standards for model years 2014 and 2015. Target line functions for 2016-2018 are for the second NHTSA alternative described in the Phase 1 preamble Section II.C (d)(ii).

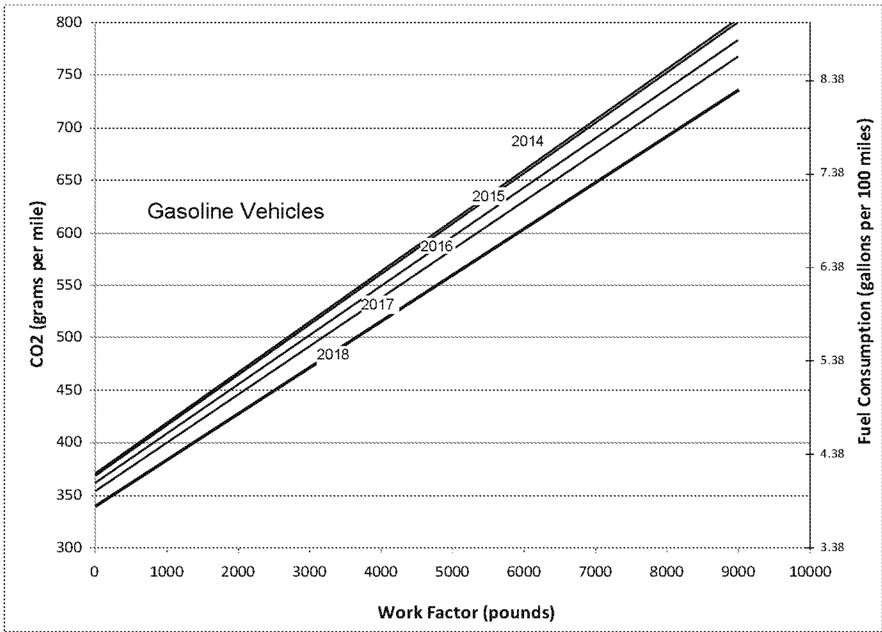


Figure VI-2: EPA Phase 1 CO_2 Target Standards and NHTSA Fuel Consumption Target Standards for Gasoline HD Pickups and Vans

EPA phased in its CO_2 standards gradually starting in the 2014 model year, at 15-20-40-60-100 percent of the model year 2018 standards stringency level in model years 2014-2015-2016-2017-2018, respectively. The phase-in takes the form of the set of target standard curves shown above, with increasing stringency in each model year. The final EPA Phase 1 standards for 2018 (including a separate standard to control air conditioning system leakage) represent an average per-vehicle reduction in GHGs of 17 percent for diesel vehicles and 12 percent for gasoline vehicles, compared to a common MY 2010 baseline. EPA also finalized a compliance alternative whereby manufacturers can phase in different percentages: 15-20-67-67-67-100 percent of the model year 2019 standards stringency level in model years 2014-2015-2016-2017-2018-2019, respectively. This compliance alternative parallels and is equivalent to NHTSA's first alternative described below.

NHTSA's Phase 1 program allows manufacturers to select one of two fuel consumption standard alternatives for model years 2016 and later. The first alternative defines individual gasoline vehicle and diesel vehicle fuel consumption target curves that will not change for model years 2016-2018, and are equivalent to EPA's 67-67-67-100 percent target curves in model years 2016-2017-2018-2019, respectively. This option is consistent with EISA requirements that NHTSA provide 4 years lead-time and 3 years of stability for standards. 49 U.S.C. Section 32902 (k)(3). The second alternative uses target curves that are equivalent to the EPA's 40-60-

100 percent target curves in model years 2016-2017-2018, respectively. Stringency for the alternatives in Phase 1 was selected by the agencies to allow a manufacturer, through the use of the credit ~~and deficit~~ carry-forward and carry-back provisions that the agencies also finalized, to meet both NHTSA fuel efficiency and EPA GHG emission standards using a single compliance strategy. If a manufacturer cannot meet an applicable standard in a given model year, it may make up its shortfall by over-complying in a subsequent year. NHTSA also allows manufacturers to voluntarily opt into the NHTSA HD pickup and van program in model years 2014 or 2015. For these model years, NHTSA's fuel consumption target curves are equivalent to EPA's target curves. The Phase 1 phase-in options are summarized in Table VI-1~~Table VI-1~~.

Table VI-1: Phase 1 Standards Phase-in Options

	2014	2015	2016	2017	2018	2019
EPA Primary Phase-in	15%	20%	40%	60%	100%	100%
EPA Compliance Option	15%	20%	67%	67%	67%	100%
NHTSA First Option	0%	0%	67%	67%	67%	100%
NHTSA Second Option	0%	0%	40%	60%	100%	100%

The form and stringency of the Phase 1 standards curves are based on the performance of a set of vehicle, engine, and transmission technologies expected (although not required) to be used to meet the GHG emissions and fuel economy standards for model year 2012-2016 light-duty vehicles, with full consideration of how these technologies are likely to perform in heavy-duty vehicle testing and use. All of these technologies are already in use or have been announced for upcoming model years in some light-duty vehicle models, and some are in use in a portion of HD pickups and vans as well. The technologies include:

- advanced 8-speed automatic transmissions
- aerodynamic improvements
- electro-hydraulic power steering
- engine friction reductions
- improved accessories
- low friction lubricants in powertrain components
- lower rolling resistance tires
- lightweighting
- gasoline direct injection
- diesel aftertreatment optimization
- air conditioning system leakage reduction (for EPA program only)

B. Proposed HD Pickup and Van Standards

As described in this section, NHTSA and EPA are proposing Phase 2 standards that become more stringent over model years 2021-2025. The agencies are proposing standards based on a year-over-year increase in stringency of 2.75% for a total increase in stringency over MYs 2021-2025 of about 13% compared to Phase 1. The agencies have analyzed several alternatives which are discussed in this section below and in Section X. In particular, we are requesting comment not only on the proposed standards but also on Alternative 4 which is based on a year-over-year increase in stringency of 3.5%, as discussed below. While we believe the preferred alternative is feasible in the time frame of this rule, and that Alternative 4 ~~While we believe both of the stringency levels discussed by the agencies are technically~~could potentially be feasible~~, in the timeframe of this rule,~~ the two stringency levels differ in the required ~~technology penetration~~adoption rate of advanced technologies for certain high volume vehicle segments. As discussed in more detail in I. A. (1) below~~C. (8) below~~, both of the considered stringency levels require comparable penetration rates of almost every technology approaching 100% penetration on most technologies, however alternative 4 would additionally require significant penetration of strong hybridization~~ as described below.~~. We request comments, additional information, data, and feedback to determine the extent to which such ~~penetration~~ adoption would be realistic within the timeframe of the rule.

When considering potential Phase 2 standards, the agencies anticipate that the technologies listed above that were considered in Phase 1 will continue to be available in the future if not already applied under Phase 1 standards and that additional technologies will also be available:

- advanced engine improvements for friction reduction and low friction lubricants
- improved engine parasitics, including fuel pumps, oil pumps, and coolant pumps
- valvetrain variable lift and timing
- cylinder deactivation
- direct gasoline injection
- cooled exhaust gas recirculation
- turbo downsizing of gasoline engines
- Diesel engine efficiency improvements
- downsizing of diesel engines
- 8-speed automatic transmissions
- electric power steering
- high efficiency transmission gear boxes and driveline
- further improvements in accessory loads
- additional improvements in aerodynamics and tire rolling resistance
- low drag brakes

- mass reduction
- mild hybridization
- strong hybridization

~~Section~~Sections VI.C. and D below and Section 2 of the Draft RIA provide a detailed analysis of these and other potential technologies for Phase 2, including their feasibility, costs, and effectiveness and projected application rates for reducing fuel consumption and CO_2 emissions when utilized in HD pickups and vans. Sections VI.C~~,~~ and D and Section X also discuss the selection of the proposed standards and the alternatives considered.

In addition to the EPA's CO_2 emission standards and NHTSA's fuel consumption standards for HD pickups and vans, EPA also finalized standards for two additional GHGs — N_2O and CH_4, as well as standards for air conditioning-related HFC emissions in the Phase 1 rule. EPA is proposing to continue these standards in Phase 2. Also, ~~as required by~~consistent with CAA section 202(a)(1), EPA finalized Phase 1 standards that apply to HD pickups and vans in use and EPA is proposing to continue the in-use standards approach in Phase 2. All of the proposed standards for these HD pickups and vans are discussed in more detail below. Program flexibilities and compliance provisions related to the standards for HD pickups and vans are discussed in Section VI.D.

A relatively small number of HD pickups and vans are sold by vehicle manufacturers as incomplete vehicles, without the primary load-carrying device or container attached. In Phase 1, we generally regulated these vehicles as Class 2b through 8 vocational vehicles but also allowed manufacturers the option to choose to comply with heavy-duty pickup or van standards. A sizeable subset of these incomplete vehicles, often called cab-chassis vehicles, are sold by the vehicle manufacturers in configurations with complete cabs and many of the components that affect GHG emissions and fuel consumption identical to those on complete pickup truck or van counterparts — including engines, cabs, frames, transmissions, axles, and wheels. As just noted, the Phase 1 program includes provisions that allow manufacturers to include these Class 2b and 3 vehicles, as well as some Class 4 through 6 vehicles, to be regulated under the chassis-based HD pickup and van program (*i.e.* subject to the standards for HD pickups and vans), rather than the vocational vehicle program.[8] The agencies are proposing to continue this approach for the Phase 2 standards. Phase 1 also includes optional compliance paths for spark-ignition engines identical to engines used in heavy-duty pickups and vans to comply with 2b/3 standards in accordance with 40 CFR 1037.150(m) and 49 CFR 535.5(a)(7). Manufacturers sell such engines as loose engines or install these engines in incomplete vehicles that are not cab-complete vehicles. The agencies are not proposing to retain the loose engine provisions for Phase 2. These program elements are discussed above in Section V on vocational vehicles.

NHTSA and EPA request comment on all aspects of the proposed HD pickup and van standards and program elements described below and the alternatives discussed in Section X.

[8] See 76 FR 57259-57260, September 15, 2011 and 78 FR 36374, June 17, 2013.

(1) Vehicle-Based Standards

For Phase 1, EPA and NHTSA chose to set vehicle-based standards whereby the entire vehicle is chassis-tested. The agencies propose to retain this approach for Phase 2. About 90 percent of Class 2b and 3 vehicles are pickup trucks, passenger vans, and work vans that are sold by the original equipment manufacturers as complete vehicles, ready for use on the road. In addition, most of these complete HD pickups and vans are covered by CAA vehicle emissions standards for criteria pollutants (*i.e.*, they are chassis tested similar to light-duty), expressed in grams per mile. This distinguishes this category from other, larger heavy-duty vehicles that typically have ~~only the~~ engines covered by CAA engine emission standards for criteria pollutants, expressed in grams per brake horsepower-hour. As a result, Class 2b and 3 complete vehicles share both substantive elements and a regulatory structure much more in common with light-duty trucks than with other heavy-duty vehicles.

Three of these features in common are especially significant: (1) over 95 percent of the HD pickups and vans sold in the United States are produced by Ford, General Motors, and Chrysler – three companies with large light-duty vehicle and light-duty truck sales in the United States; (2) these companies typically base their HD pickup and van designs on higher sales volume light-duty truck platforms and technologies, often incorporating new light-duty truck design features into HD pickups and vans at their next design cycle, and (3) at this time most complete HD pickups and vans are certified to vehicle-based rather than engine-based EPA criteria pollutant and GHG standards. There is also the potential for substantial GHG and fuel consumption reductions from vehicle design improvements beyond engine changes (such as through optimizing aerodynamics, weight, tires, and accessories), and ~~the~~a single manufacturer is generally responsible for both engine and vehicle design. All of these factors together suggest that it is still appropriate and reasonable to base standards on performance of the vehicle as a whole, rather than to establish separate engine and vehicle GHG and fuel consumption standards, as is being done for the other heavy-duty categories. The chassis-based standards approach for complete vehicles was also consistent with NAS recommendations and there was consensus in the public comments on the Phase 1 proposal supporting this approach. For all of these reasons, the agencies continue to believe that establishing chassis-based standards for Class 2b and 3 complete vehicles is appropriate for Phase 2.

(a) Work-Based Attributes

In developing the Phase 1 HD rulemaking, the agencies emphasized creating a program structure that would achieve reductions in fuel consumption and GHGs based on how vehicles are used and on the work they perform in the real world. Work-based measures such as payload and towing capability are key among the things that characterize differences in the design of vehicles, as well as differences in how the vehicles will be used. Vehicles in the 2b and 3 categories have a wide range of payload and towing capacities. These work-based differences in design and in-use operation are key factors in evaluating technological improvements for reducing CO_2 emissions and fuel consumption. Payload has a particularly important impact on the test results for HD pickup and van emissions and fuel consumption, because testing under existing EPA procedures for criteria pollutants and the Phase 1 standards is conducted with the vehicle loaded to half of its payload capacity (rather than to a flat 300 lb as in the light-duty program), and the correlation between test weight and fuel use is strong.

Towing, on the other hand, does not directly factor into test weight as nothing is towed during the test. Hence, setting aside any interdependence between towing capacity and payload, only the higher curb weight caused by any heavier truck components would play a role in affecting measured test results. However towing capacity can be a significant factor to consider because HD pickup truck towing capacities can be quite large, with a correspondingly large effect on vehicle design.

We note too that, from a purchaser perspective, payload and towing capability typically play a greater role than physical dimensions in influencing purchaser decisions on which heavy-duty vehicle to buy. For passenger vans, seating capacity is of course a major consideration, but this correlates closely with payload weight.

For these reasons, EPA and NHTSA set Phase 1 standards for HD pickups and vans based on a "work factor" attribute that combines vehicle payload capacity and vehicle towing capacity, in lbs, with an additional fixed adjustment for four-wheel drive (4wd) vehicles. This adjustment accounts for the fact that 4wd, critical to enabling many off-road heavy-duty work applications, adds roughly 500 lb to the vehicle weight. The work factor is calculated as follows: 75% maximum payload + 25% of maximum towing + 375 lbs if 4wd. Under this approach, target GHG and fuel consumption standards are determined for each vehicle with a unique work factor (analogous to a target for each discrete vehicle footprint in the light-duty vehicle rules). These targets will then be production weighted and summed to derive a manufacturer's annual fleet average standard for its heavy-duty pickups and vans. There was widespread support (and no opposition) for the work factor-based approach to standards and fleet average approach to compliance expressed in the comments we received on the Phase 1 rule. The agencies are proposing to continue using the work factor attribute for the Phase 2 standards and request comments on continuing this approach.

Recognizing that towing is not reflected in the test for these vehicles, however, the agencies are requesting comment with respect to the treatment of towing in the work factor, especially for diesel vehicles. More specifically, does using the existing the work factor equation create an inappropriate incentive for manufacturers to provide more towing capability than needed for some operators, or a disincentive for manufacturers to develop vehicles with intermediate capability~~?~~. In other words, does it encourage "surplus" towing capability~~?~~ that has no value to vehicle owners and operators? We recognize that some owners and operators do actually use their vehicles to tow very heavy loads, ~~but many~~and that some owners and operators who rarely use their vehicles to tow heavy loads nonetheless prefer to own vehicles capable of doing so. However, others ~~will~~may never tow such heavy loads and purchase their vehicles ~~because of~~for other reasons, such as cargo capacity or off-road capability. Some of these ~~lighter~~less demanding (in terms of towing) users may choose to purchase gasoline-powered vehicles that are typically less expensive and have lower GCWR values, an indicator of towing capability. However, others ~~may be best suited by a vehicle that has an~~could prefer a diesel engine more powerful than today's gasoline engines but less powerful than the typical diesel engines found in 2b and 3 pickups today. In this context, the agencies are considering ~~three~~(but have not yet evaluated) four possible changes to the work factor and how it is applied. First, the agencies are considering revising the work factor to weight payload by 80 percent and towing by 20 percent. Second, we are considering capping the amount of towing that could be credited in the work factor. For example, the work factors for all vehicles with towing ratings above 15,000 lbs could be calculated based on a towing rating of 15,000 lbs. It is important to be clear that such a provision would not limit the towing capability manufacturers could provide, but would only impact the extent to which the work factor~~. Finally~~ would "reward" towing capability. Third, the agencies are considering changing the shape of the standard curve for diesel vehicles to become more flat at very high work factors. A flatter curve would mean that vehicles with very high work factors would be more similar to vehicles with lower work factors than is true for the proposed curve. Thus, conceptually, flattening the curves at the high end might be appropriate if we were to determine that these high work factor vehicles actually operate more similar to the less capable vehicles. For example, when not towing and when not hauling a full payload, heavy-duty pickup trucks with very different work factors may actually be performing the same work. Finally, we are considering having different work factor formulas for pickups and vans, and whether any of other changes should be applied differently to pickups than to vans. We welcome comments on both the extent to which surplus towing may be an issue and whether any of the potential changes discussed above would be appropriate. Commenters supporting such changes are encouraged to also address ~~other changes that would be necessary in conjunction with these changes.~~any potential accompanying changes. For example, if we reweight the work factor, would ~~we need~~ other changes to ~~finalize different numerical~~ the coefficients defining the target curves be important to ensure that standards~~?~~ remain at the maximum feasible levels. (Commenters should, however, recognize that average requirements will, in any event, depend on fleet mix, and the agencies expect to update estimates of future fleet mix before issuing a final rule.)

As noted in the Phase 1 rule, the attribute-based CO_2 and fuel consumption standards are meant to be as consistent as practicable from a stringency perspective. Vehicles across the entire range of the HD pickup and van segment have their respective target values for CO_2 emissions and fuel consumption, and therefore all HD pickups and vans will be affected by the standard. With this attribute-based standards approach, EPA and NHTSA believe there should be no significant effect on the relative distribution of vehicles with differing capabilities in the fleet, which means that buyers should still be able to purchase the vehicle that meets their needs.

(b) Standards

The agencies are proposing Phase 2 standards based on~~ a technology~~ analysis performed to determine the appropriate HD pickup and van standards for MYs 2021-2025. This analysis, described below and in the Draft RIA, considered:

- projections of future U.S. sales for HD pickup and vans
- the estimates of corresponding CO_2 emissions and fuel consumption for these vehicles
- forecasts of manufacturers' product redesign schedules

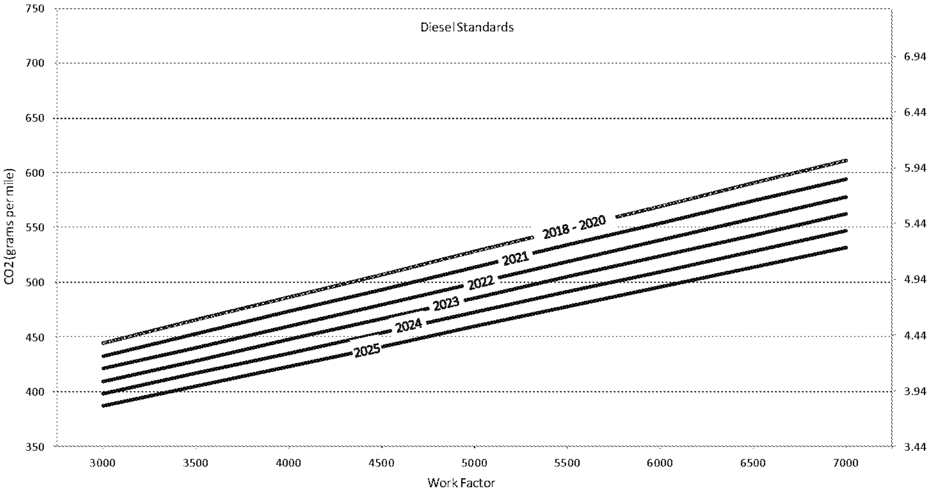
- the technology available in new MY 2014 HD pickups and vans to specify preexisting technology content to be included in the analysis fleet (the fleet of vehicles used as a starting point for analysis) extending through MY 2030
- the estimated effectiveness, cost, applicability, and availability of technologies for HD pickup and vans
- manufacturers' ability to use credit carry-forward
- the levels of technology that are projected to be added to the analysis fleet through MY 2030 considering improvements needed in order to achieve compliance with the Phase 1 standards (thus defining the reference fleet–*i.e.*, under the No-Action Alternative—relative to which to measure incremental impacts of Phase 2 standards~~)~~), and
- the levels of technology that are projected to be added to the analysis fleet through MY2030 considering further improvements needed in order to achieve compliance with standards defining each regulatory (action) alternative for Phase 2.

Based on this analysis, EPA is proposing CO_2 attribute-based target standards shown in Figure VI-3~~Figure VI-3~~ and Figure VI-4~~Figure VI-4~~, and NHTSA is proposing the equivalent attribute-based fuel consumption target standards, also shown in Figure VI-3~~Figure VI-3~~ and Figure VI-4~~Figure VI-4~~, applicable in model year 2019-2025. The agencies are not proposing to change the standards for 2018-2020 and therefore the standards would remain stable at the MY 2018 Phase 1 levels for MYs 2019 and 2020. EISA requires four years of lead-time and three years stability for NHTSA standards and this period of lead-time and stability for 2018-2020 is consistent with the EISA requirements. For MYs 2021-2025, the agencies are proposing annual reductions in the standards as the primary phase-in of the Phase 2 standards. The proposed standards become 13% more stringent overall between MY 2020 and MY 2025. This approach to the Phase 2 standards as a whole can be considered a phase-in or implementation schedule of the ~~final~~proposed MY 2025 standards (which would apply thereafter unless and until amended).

For EPA, Section 202(a) provides the Administrator with the authority to establish standards, and to revise those standards "from time to time", thus providing the Administrator with considerable discretion in deciding when to revise the Phase 1 MY 2018 standards. EISA requires that NHTSA provide 4 full model years of regulatory lead time and 3 full model years of regulatory stability for its fuel economy standards. 49 U.S.C. 32902(k)(3). ~~For this proposal, EPA~~ Consistent with these authorities, the agencies are~~is~~ proposing more stringent standards beginning with MY 2021 that consider the level of technology we predict can be applied to new vehicles in the 2021 MY. EPA believes the proposed Phase 2 standards are consistent with CAA requirements regarding lead-time, reasonable cost, and feasibility. Manufacturers in the HD pickup and van market segment have relatively few vehicle lines and redesign cycles are typically longer compared to light-duty vehicles. Also, the timing of vehicle redesigns differs among manufacturers. ~~The proposed Phase 2 standards would not be fully phased in until MY 2025~~ To provide lead time needed to accommodate these longer redesign cycles~~ and allow for~~, the ~~complete transition of a manufacturer's fleet to the new standards.~~proposed Phase 2 GHG standards would not reach their tightest stringency until 2025. Although the standards are proposed to decrease over time between MYs 2021~~-~~ and 2025, the agencies ~~do not~~ expect ~~each manufacturer~~manufacturers will likely strive to make ~~changes in every year.~~improvements as part of planned redesigns, such that some model years will likely involve significant advances, while other model years will likely involve little change. The agencies also expect manufacturers to use program flexibilities (e.g., credit carry-forward provisions and averaging, banking, and trading provisions ~~to smooth the transition to the final MY 2025 standards~~) to help balance compliance costs over time. The agencies are proposing to provide stable standards in MYs 2019-2020 in order to provide necessary lead time for Phase 2. However, for some manufacturers, the transition to the Phase 2 standards may begin ~~early in the MY 2019-2020 time frame~~earlier (e.g., as soon as MY 2017) depending on their vehicle redesign cycles. Although standards are not proposed to change in MYs 2019-2020, manufacturers may introduce additional ~~"Phase 2"~~ technologies in order to carry forward corresponding improvements and perhaps generate credits under the 5 year credit carry-forward provisions established in Phase 1 and proposed to continue for Phase 2 to be used in the MY 2021-2025 time frame. Section VI.C and D below provides additional discussion of vehicle redesign cycles and the feasibility of the proposed standards.

As in Phase 1, these standards would be met on a fleet average basis. No individual vehicle would have to meet a particular fleet average standard. Nor would all manufacturers have to meet ~~the same standard.~~numerically identical fleet average requirement. Rather, each manufacturer would have its own unique ~~standard,~~fleet average requirement based on the production- weighted average of the heavy duty pickups and vans it chooses to produce. Moreover, averaging, banking, and trading provisions, discussed below, provide significant additional compliance flexibility in implementing the standards. It is important to note, however, that while the standards would differ numerically from manufacture to manufacturer, effective stringency should be essentially the same for each manufacturer.

Also, as with the Phase 1 standards, the agencies are proposing separate Phase 2 targets for gasoline-fueled (and any other Otto-cycle) vehicles and diesel-fueled (and any other diesel-cycle) vehicles. The targets would be used to determine the production-weighted fleet average standards that apply to the combined diesel and gasoline fleet of HD pickups and vans produced by a manufacturer in each model year. The above-proposed stringency increase for Phase 2 applies equally to the separate gasoline and diesel targets. The agencies considered different rates of increase for the gasoline and diesel targets in order to more equally balance compliance burdens across manufacturers with varying gasoline/diesel fleet mixes. However, at least among major HD pickup and van manufacturers, our analysis suggests limited potential for such optimization, especially considering uncertainties involved with manufacturers' future fleet mix. The agencies have thus maintained the equivalent rates of stringency increase. The agencies invite comment on this element.


Diesel Standards
CO2 (grams per mile)
Work Factor
750
700
650
600
550
500
450
400
350
3000
3500
4000
4500
5000
5500
6000
6500
7000
6.94
6.44
5.94
5.44
4.94
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3.94
3.44
2018 - 2020
2021
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Figure VI-3: EPA Proposed CO_2 Target Standards and NHTSA Fuel Consumption Target Standards for Diesel HD Pickups and Vans

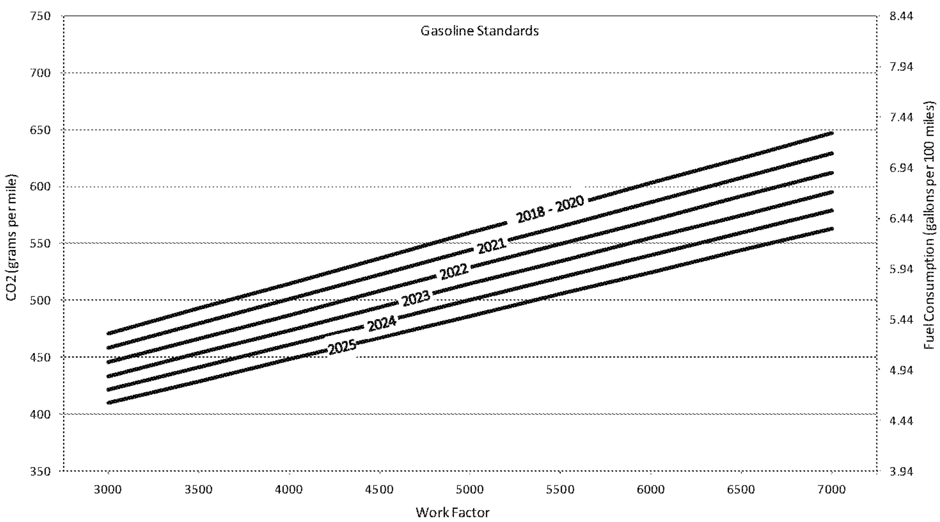

Figure VI-4: EPA Proposed CO_2 Target Standards and NHTSA Fuel Consumption Target Standards for Gasoline HD Pickups and Vans

Described mathematically, EPA's and NHTSA's proposed target standards are defined by the following ~~formulae~~formulas:

EPA CO_2 Target (g/mile) = [a x WF] + b

NHTSA Fuel Consumption Target (gallons/100 miles) = [c x WF] + d

Where:

WF = Work Factor = [0.75 x (Payload Capacity + xwd)] + [0.25 x Towing Capacity]

Payload Capacity = GVWR (lb) – Curb Weight (lb)

xwd = 500 lb if the vehicle is equipped with 4wd, otherwise equals 0 lb.

Towing Capacity = GCWR (lb) – GVWR (lb)

~~Page of~~

Coefficients a, b, c, and d are taken from Table VI-2~~Table VI-2~~.

Table VI-2: Proposed Phase 2 Coefficients for HD Pickup and Van Target Standards

Diesel Vehicles				
Model Year	a	b	c	d
2018-2020	0.0416	320	0.000409	3.14
2021	0.0405	311	0.000398	3.05
2022	0.0393	303	0.000387	2.97
2023	0.0383	294	0.000376	2.89
2024	0.0372	286	0.000366	2.81
2025 and later	0.0362	278	0.000356	2.73
Gasoline Vehicles				
Model Year	a	b	c	d
2018-2020	0.0440	339	0.000495	3.81
2021	0.0428	330	0.000481	3.71
2022	0.0416	321	0.000468	3.60
2023	0.0405	312	0.000455	3.50
2024	0.0394	303	0.000443	3.41
2025 and later	0.0383	295	0.000431	3.31

As noted above, the standards are not proposed to change from the final Phase 1 standards for MYs 2018-2020. The MY 2018-2020 standards are shown in the Figures and tables above for reference.

NHTSA and EPA have also analyzed regulatory alternatives to the proposed standards, as discussed in Section VI.C and D and Section X. below. The agencies request comments on all of the alternatives analyzed for the proposal, but request comments on Alternative 4 or a stringency level between the ~~proposal~~ proposed Alternative 3 and Alternative 4 in particular. Alternative 4 is based on an annual improvement of 3.5% per year in MYs 2021-2025 compared to the 2.75% per year improvement on which the proposal is based. The agencies are seriously considering whether this ~~more stringent alternative~~Alternative 4, or ~~something~~ increments between the two stringency levels for HD pickups and vans, would be realistic and feasible, as described in Section VI.C and D, Section X, and in the Draft RIA Chapter 9. ~~This alternative~~Alternative 4 is predicated on somewhat more aggressive adoption rates of the same technologies on which the proposed Alternative 3 ~~proposal~~ is predicated~~, and a choice of this alternative would reflect a different balancing of the relevant factors under the respective statutory authorities.~~. ~~The agencies request comment on all aspects of this alternative.~~The agencies request ~~detailed~~comments, data, and information that would help inform determination of the maximum feasible (for NHTSA) and appropriate (for EPA) stringency for HD pickups and vans and are particularly interested in information and data related to the expected adoption rates of different emerging technologies, such as mild and strong hybridization.

As with Phase 1 standards, to calculate a manufacturer's HD pickup and van fleet average standard, the agencies are proposing separate target curves be used for gasoline and diesel vehicles. The agencies estimate that in 2025 the proposed target curves would achieve approximately 13 percent reductions in CO_2 and fuel consumption for both diesel and gasoline vehicles relative to the MY 2018 Phase 1 standards for HD pickup trucks and vans. These reductions are based on the agencies' assessment of the feasibility of incorporating technologies (which differ significantly for gasoline and diesel powertrains) in the 2021-2025 model years, and on the differences in relative efficiency in the current gasoline and diesel vehicles ~~once the Phase 1 standards are fully implemented~~.

The agencies generally prefer to set standards that do not distinguish between fuel types where technological or market-based reasons do not strongly argue otherwise. However, as with Phase 1, we continue to believe that fundamental differences between spark ignition and compression ignition engines warrant unique fuel standards, which is also important in ensuring that our program maintains product choices available to vehicle buyers. In fact, gasoline and diesel fuel behave so differently in the internal combustion engine that they have historically required unique test procedures, emission control technologies and emission standards. These technological differences between gasoline and diesel engines for GHGs and fuel consumption exist presently and will continue to exist after Phase 1 and through Phase 2 until advanced research evolves the gasoline fueled engine to diesel-like efficiencies. This will require significant technological breakthroughs currently in early stages of research such as homogeneous charge compression ignition (HCCI) or similar concepts. Because these technologies are still in the early research stages, we believe the proposed separate fuel type standards are appropriate in the timeframe of this rule to protect for the availability of both gasoline and diesel engines and will result in roughly equivalent redesign burdens for engines of both fuel types as evident by feasibility and cost analysis in RIA Chapter 2. The agencies request comment on the level of stringency of the proposed standards, the continued separate targets for gasoline and diesel HD pickups and vans, and the continued use of the work-based attribute approach described above.

The proposed NHTSA fuel consumption target curves and the EPA GHG target curves are equivalent. The agencies established the target curves using the direct relationship between fuel consumption and CO_2 using conversion factors of 8,887 g CO_2/gallon for gasoline and 10,180 g CO_2/gallon for diesel fuel.

It is expected that measured performance values for CO_2 will generally be equivalent to fuel consumption. However, Phase 1 established a provision that EPA is not proposing to change for Phase 2 that allows manufacturers, if they choose, to use CO_2 credits to help demonstrate compliance with N_2O and CH_4 emissions standards, by expressing any N_2O and CH_4 under compliance in terms of their CO_2-equivalent and applying the needed CO_2 credits. For test families that do not use this compliance alternative, the measured performance values for CO_2 and fuel consumption will be equivalent because the same test runs and measurement data will be used to determine both values, and calculated fuel consumption will be based on the same conversion factors that are used to establish the relationship between the CO_2 and fuel consumption target curves (8,887 g CO_2/gallon for gasoline and 10,180 g CO_2/gallon for diesel fuel). For manufacturers that choose to use the EPA provision for CO_2 credit use in demonstrating N_2O and CH_4 compliance, compliance with the CO_2 standard will not be directly equivalent to compliance with the NHTSA fuel consumption standard.

(2) What Are the HD Pickup and Van Test Cycles and Procedures~~?~~

The Phase 1 program established testing procedures for HD pickups and vans and NHTSA and EPA are not proposing to change these testing protocols. The vehicles would continue to be tested using the same heavy-duty chassis test procedures currently used by EPA for measuring criteria pollutant emissions from these vehicles, but with the addition of the highway fuel economy test cycle (HFET). These test procedures are used by manufacturers for certification and emissions compliance demonstrations and by the agencies for compliance verification and enforcement. Although the highway cycle driving pattern is identical to that of the light-duty test, other test parameters for running the HFET, such as test vehicle loaded weight, are identical to those used in running the current EPA Federal Test Procedure for ~~EPA criteria pollutant standards for~~ complete heavy-duty vehicles. Please see Section II.C (2) of the Phase 1 preamble (76 FR 57166) for a discussion of how HD pickups and vans would be tested.

One item that the agencies are considering to change is how vehicles are categorized into test weight bins. Under the current test procedures, vehicles are tested at 500 lb increments of inertial weight classes when testing at or above 5500 lbs test weight. ~~However~~ For example, all vehicles having a calculated test weight basis of 11251 to 11750 pounds would be tested 11,500 pounds (i.e., the midpoint of the range). However, for some vehicles, the existence of these bins and the large intervals between bins may reduce or eliminate the incentive for mass reduction for some vehicles, as a vehicle may require significant mass reduction before it could switch from one test weight bin to the next lower bin. For other vehicles, these bins may unduly reward relatively small reductions of vehicle mass, as a vehicle's mass may be only slightly greater than that needed to be assigned a 500-pound lighter inertia weight class. For example, for a vehicle with a calculated test weight basis of 11,700 pounds, a manufacturer would receive no regulatory benefit for reducing the vehicle weight by 400 pounds, because the vehicle would stay within the same weight bracket. The agencies do recognize that the test weight bins allow for some reduction in testing burden as many vehicles can be grouped together under a single test. For Phase 2, the agencies seek comment on whether the test weight bins should be changed in order to allow for more realistic testing of HD pickups and vans and better capture of the improvements due to mass reduction. Some example changes could include reducing the five hundred pound interval between bins to smaller intervals similar to those allowed for vehicles tested below 5500 lbs. test weight, or allowing any test weight value that is not fixed to a particular test weight bin. The latter scenario would still allow some grouping of vehicles to reduce test burden, and the agencies also seek comment on how vehicles would be grouped and how the test weight of this group of vehicles should be selected.

We further seek comment as to whether there may be a more appropriate method such as allowing analytical adjustment of the CO_2 levels and fuel consumption within a vehicle weight class to more precisely account for the individual vehicle models performance. For example, could an equation like the one specified in 40 CFR 1037.104(g) for analytically adjusting CO2 emissions be used. The agencies are specifically considering an approach in which vehicles are tested in the same way with the same test weights, but manufacturers have the option to either accept the emission results as provided under the current regulations, or choose to adjust the emissions based on the actual test weight basis (actual curb plus half payload) instead of the equivalent test weight for the 500 test weight interval. Should the agencies finalize this as an option, manufacturers choosing to adjust their emissions would be required to do so for all of their vehicles, and not just for those with test weights below the midpoint of the range.

(3) Fleet Average Standards

NHTSA and EPA are proposing to retain the fleet average standards approach finalized in the Phase 1 rule and structurally similar to light-duty Corporate Average Fuel Economy (CAFE) and GHG standards. The fleet average standard for a manufacturer is a production-weighted average of the work factor-based targets assigned to unique vehicle configurations within each model type produced by the manufacturer in a model year. Each manufacturer would continue to have an average GHG requirement and an average fuel consumption requirement unique to its new HD pickup and van fleet in each model year, depending on the characteristics (payload, towing, and drive type) of the vehicle models produced by that manufacturer, and on the U.S.-directed production volume of each of those models in that model year. Vehicle models with larger payload/towing capacities and/or four-wheel drive have individual targets at numerically higher CO_2 and fuel consumption levels than less capable vehicles, as discussed in Section VI.B(1). ~~The fleet average standard for a manufacturer is a production-weighted average of the work factor-based targets assigned to unique vehicle configurations within each model type produced by the manufacturer in a model year.~~

The fleet average standard with which the manufacturer must comply ~~is~~would continue to be based on its final production figures for the model year, and thus a final assessment of compliance ~~will~~would occur after production for the model year ends. The assessment of compliance also must consider the manufacturer's use of carry-forward and carry-back credit provisions included in the averaging, banking, and trading program. Because compliance with the fleet average standards depends on actual test group production volumes, it is not possible to determine compliance at the time the manufacturer applies for and receives an (initial) EPA certificate of conformity for a test group. Instead, at certification the manufacturer would demonstrate a level of performance for vehicles in the test group, and make a good faith demonstration that its fleet, regrouped by unique vehicle configurations within each model type, is expected to comply with its fleet average standard when the model year is over. EPA will issue a certificate for the vehicles covered by the test group based on this demonstration, and will include a condition in the certificate that if the manufacturer does not comply with the fleet average, then production vehicles from that test group will be treated as not covered by the certificate to the extent needed to bring the manufacturer's fleet average into compliance. As in the parallel program for light-duty vehicles, additional "model type" testing will be conducted by the manufacturer over the course of the model year to supplement the initial test group data. The emissions and fuel consumption levels of the test vehicles will be used to calculate the production-weighted fleet averages for the manufacturer, after application of the appropriate deterioration factor to each result to obtain a full useful life value. Please see Section II.C (3)(a) of the Phase 1 preamble (76 FR 57167) for further discussion of the fleet average approach for HD pickups and vans.

(4) In-use Standards

Section 202(a)(1) of the CAA specifies that EPA set emissions standards that are applicable for the useful life of the vehicle. EPA is proposing to continue the in-use standards approach for individual vehicles that EPA finalized for the Phase 1 program. NHTSA did not adopt Phase 1 in-use standards and is not proposing in-use standards for Phase 2. For the EPA program, compliance with the in-use standard for individual vehicles and vehicle models does not impact compliance with the fleet average standard, which will be based on the production-weighted average of the new vehicles. Vehicles that fail to meet their in-use emission standards would be subject to recall to correct the noncompliance.

As with Phase 1, EPA proposes that the in-use Phase 2 standards for HD pickups and vans be established by adding an adjustment factor to the full useful life emissions used to calculate the GHG fleet average. EPA proposes that each model's in-use CO_2 standard be the model-specific level used in calculating the fleet average, plus 10 percent. No adverse comments were received on this provision during the Phase 1 rulemaking. Please see Section II.C (3)(b) of the Phase 1 preamble (76 FR 57167) for further discussion of in-use standards for HD pickups and vans.

For Phase 1, EPA aligned the useful life for GHG emissions with the useful life ~~already~~that was in place for criteria pollutants: 11 years or 120,000 miles, whichever occurs first (40 CFR 86.1805-04(a)). Since the Phase 1 rule was finalized, EPA updated the useful life for criteria pollutants as part of the Tier 3 rulemaking.[9] The new useful life implemented for Tier 3 is 150,000 miles or 15 years, whichever occurs first. EPA proposes that the useful life for GHG emissions also be updated to 150,000 miles/15 years starting in MY 2021 when the Phase 2 standards begin so that the useful life remains aligned for GHG and criteria pollutant standards long term. With the relatively flat deterioration generally associated with CO_2 and the proposed in-use standard adjustment factor discussed above, EPA does not believe the proposed change in useful life would significantly affect the feasibility of the proposed Phase 2 standards.[10] EPA requests comments on the proposed change to useful life.

[9] 79 FR 23492, April 28, 2014 and 40 CFR 86.1805-17.

[10] As discussed below in Section VI.D.1., EPA and NHTSA are proposing an adjustment factor of 1.25 for banked credits that are carried over from Phase 1 to Phase 2. The useful life is factored into the credits calculation and without the adjustment factor the change in useful life would effectively result in a discount of those carry-over credits.

(5) Other GHG Standards for HD Pickups and Vans

This section addresses greenhouse gases other than CO2. Note that since these are greenhouse gases not directly related to fuel consumption, NHTSA does not have equivalent standards.

(a) Nitrous Oxide (N_2O) and Methane (CH_4)

In the Phase 1 rule, EPA established emissions standards for HD pickups and vans for both nitrous oxide (N_2O) and methane (CH_4). Similar to the CO_2 standard approach, the N_2O and CH_4 emission level of a vehicle are based on a composite of the light-duty FTP and HFET cycles with the same 55 percent city weighting and 45 percent highway weighting. The N_2O and CH_4 standards were both set by EPA at 0.05 g/mile. Unlike the CO_2 standards, averaging between vehicles is not allowed. The standards are designed to prevent increases in N_2O and CH_4 emissions from current levels, *i.e.*, a no-backsliding standard. EPA is not proposing to change the N_2O or CH_4 standards or related provisions established in the Phase 1 rule. Please see Phase 1 preamble Section II.E. (76 FR 57188-57193) for additional discussion of N_2O and CH_4 emissions and standards.

Across both current gasoline- and diesel-fueled heavy-duty vehicle designs, emissions of CH_4 and N_2O are relatively low and the intent of the cap standards is to ensure that future vehicle technologies or fuels do not result in an increase in these emissions. ~~For~~Given the global warning potential (GWP) of CH_4, the 0.05 g/mile cap standard is equivalent to about 1.25 g/mile CO_2, which is much less than 1 percent of the overall GHG emissions of most HD pickups and vans.[11] The effectiveness of oxidation of CH_4 using a three-way or diesel oxidation catalyst is limited by the activation energy~~. Thus as~~, which tends to be higher where the number of carbon atoms in the hydrocarbon molecule ~~decrease, the activation energy increases.~~is low and thus CH_4 is very stable. At this time we are not aware of any technologies beyond the already present catalyst systems which are highly effective at oxidizing most hydrocarbon species for gasoline and diesel fueled engines that would further lower the activation energy across the catalyst or increase the energy content of the exhaust (without further increasing fuel consumption and CO_2 emissions) to further reduce CH_4 emissions at the tailpipe. ~~EPA knows~~We note that we are not aware of ~~no~~any new technologies that would ~~lower CH_4 emissions beyond the control provided by the precise emissions control systems already being implemented~~allow us to ~~meet EPA's criteria pollutant~~adopt more stringent standards at this time. The CH_4 standard remains an important backstop to prevent future increases in CH_4 emissions, particularly with the potential for expanded use of alternative fuels like CNG.

N_2O is emitted from gasoline and diesel vehicles mainly during specific catalyst temperature conditions conducive to N_2O formation. The 0.05 g/mile standard, which translates to a CO_2-equivalent value of 14.9 g/mile, ensures that systems are not designed in a way that emphasizes efficient NOx control while allowing the formation of significant quantities of N_2O.

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[11] N_2O has a GWP of 298 and CH_4 has a GWP of 25 according to the IPCC AR4.

The Phase 1 N_2O standard of 0.05 g/mile for pickups and vans was finalized knowing that it is more stringent than the Phase 1 N_2O engine standard of 0.10 g/hp-hr, currently being revaluated as discussed in Preamble Section 2. EPA continues to believe that the 0.05 g/mile standard provides the necessary assurance that N_2O will not significantly increase~~.~~, given the mix of gasoline and diesel fueled engines in this market and the upcoming implementation of the light-duty and heavy-duty (up to 14,000 lbs. GVWR) Tier 3 NOx standards. EPA knows of no technologies that would lower N_2O emissions beyond the control provided by the precise emissions control systems already being implemented to meet EPA's criteria pollutant standards. Therefore, EPA continues to believe the 0.05 g/mile N_2O standard remains appropriate.

~~As noted above,~~ If a manufacturer is unable to meet the N_2O or CH_4 cap standards, the EPA program allows the manufacturer to comply using CO_2 credits. In other words, a manufacturer may offset any N_2O or CH_4 emissions above the standard by taking steps to further reduce CO_2. A manufacturer choosing this option would use GWPs to convert its measured N_2O and CH_4 test results that are in excess of the applicable standards into CO_2eq to determine the amount of CO_2 credits required. For example, a manufacturer would use 25 Mg of positive CO_2 credits to offset 1 Mg of negative CH_4 credits or use 298 Mg of positive CO_2 credits to offset 1 Mg of negative N_2O credits.[12] By using the ~~Global Warming Potential~~GWP of N_2O and CH_4, the approach recognizes the inter-correlation of these compounds in impacting global warming and is environmentally neutral for demonstrating compliance with the individual emissions caps. Because fuel conversion manufacturers certifying under 40 CFR Part 85, subpart F do not participate in ABT programs, EPA included in the Phase 1 rule a compliance option for fuel conversion manufacturers to comply with the N_2O and CH_4 standards that is similar to the credit program described above. See 76 FR 57192/3. The compliance option will allow conversion manufacturers, on an individual engine family basis, to convert CO_2 over compliance into CO_2 equivalents of N_2O and/or CH_4 that can be subtracted from the CH_4 and N_2O measured values to demonstrate compliance with CH_4 and/or N_2O standards. EPA did not include similar provisions allowing over compliance with the N_2O or CH_4 standards to serve as a means to generate CO_2 credits because the CH_4 and N_2O standards are cap standards representing levels that all but the worst vehicles should already be well below. Allowing credit generation against such cap standard would provide a windfall credit without any true GHG reduction. EPA proposes to maintain these provisions for Phase 2 as they provide important flexibility without reducing the overall GHG benefits of the program.

(b) Air Conditioning Related Emissions

Air conditioning systems contribute to GHG emissions in two ways – direct emissions through refrigerant leakage and indirect exhaust emissions due to the extra load on the vehicle's engine to provide power to the air conditioning system. HFC refrigerants, which are powerful GHG pollutants, can leak from the A/C system. This includes the direct leakage of refrigerant as well as the subsequent leakage associated with maintenance and servicing, and with disposal at

[12] N_2O has a GWP of 298 and CH_4 has a GWP of 25 according to the IPCC AR4.

the end of the vehicle's life.[13] Currently, the most commonly used refrigerant in automotive applications – R134a, has a high GWP~~ of 1430.~~[14]. Due to the high GWP of R134a, a small leakage of the refrigerant has a much greater global warming impact than a similar amount of emissions of CO_2 or other mobile source GHGs.

In Phase 1, EPA finalized low leakage requirement for all air conditioning systems installed in 2014 model year and later HDVs, with the exception of Class 2b-8 vocational vehicles. As discussed in Section V.B.3, EPA is proposing to extend leakage standards to vocational vehicles for Phase 2. For air conditioning systems with a refrigerant capacity greater than 733 grams, EPA finalized a leakage standard which is a "percent refrigerant leakage per year" to assure that high-quality, low-leakage components are used in each air conditioning system design. EPA finalized a standard of 1.50 percent leakage per year for heavy-duty pickup trucks and vans and Class 7 and 8 tractors. See Section II.E.5. of the Phase 1 preamble (76 FR 57194-57195) for further discussion of the A/C leakage standard.

Manufacturers can choose to reduce A/C leakage emissions in two ways. First, they can utilize leak-tight components. Second, manufacturers can largely eliminate the global warming impact of leakage emissions by adopting systems that use an alternative, low-Global Warming Potential (GWP) refrigerant. One alternative refrigerant, HFO-1234yf, with a GWP of 4, has been approved for use in light-duty passenger vehicles under EPA's Significant New Alternatives Program (SNAP). While the scope of this SNAP approval does not include heavy-duty highway vehicles, we expect that those interested in using this refrigerant in other sectors may petition EPA for broader approval of its use in all mobile air conditioning systems. Given that HFO-1234yf is yet to be approved for heavy-duty vehicles EPA believes that a leakage standard for heavy-duty vehicles is still appropriate. If future heavy-duty vehicles adopt refrigerants other than R-134a, the calculated refrigerant leak rate can be adjusted by multiplying the leak rate by the ratio of the GWP of the new refrigerant divided by the GWP of the old refrigerant (*e.g.* for HFO-1234yf replacing R-134a, the calculated leak rate would be multiplied by 0.0028, or 4 divided by 1430). EPA is not proposing to change the leakage standard or related provisions for Phase 2. This is similar to the approach proposed for vocational vehicles and tractors.

In addition to direct emissions from refrigerant leakage, air conditioning systems also create indirect exhaust emissions due to the extra load on the vehicle's engine to provide power to the air conditioning system. These indirect emissions are in the form of the additional CO_2 emitted from the engine when A/C is being used due to the added loads. Unlike direct emissions which tend to be a set annual leak rate not directly tied to usage, indirect emissions are fully a function of A/C usage. These indirect CO_2 emissions are associated with air conditioner

[13] The U.S. EPA has reclamation requirements for refrigerants in place under Title VI of the Clean Air Act.

~~[14] The global warming potentials used in this rule are consistent with the 2007 Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report. At this time, the global warming potential values from the 1996 IPCC Second Assessment Report are used in the official U.S. greenhouse gas inventory submission to the United Nations Framework Convention on Climate Change (per the reporting requirements under that international convention, which were last updated in 2006).~~

efficiency, since (as just noted) air conditioners create load on the engine. *See* 74 FR 49529. In Phase 1, the agencies did not set air conditioning efficiency standards for vocational vehicles, combination tractors, or heavy-duty pickup trucks and vans. The CO_2 emissions due to air conditioning systems in these heavy-duty vehicles were estimated to be minimal compared to their overall emissions of CO_2. This continues to be the case. For this reason, EPA is not proposing to establish standards for A/C efficiency for Phase 2.

NHTSA and EPA request comments on all aspects of the proposed HD pickup and van standards and program elements described in this section.

C. Feasibility of Pickup and Van Standards

EPCA/EISA requires NHTSA to "implement a commercial medium- and heavy-duty on-highway vehicle and work truck fuel efficiency improvement program designed to achieve the maximum feasible improvement" and to establish corresponding fuel economy standards "that are appropriate, cost-effective, and technologically feasible."[15] ~~The Clean Air Act requires EPA to [EPA should finish this sentence].~~ Title II of the Clean Air Act requires EPA to establish standards for emissions of pollutants from new motor vehicles and engines which emissions cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare. When acting under Title II of the CAA, EPA considers such issues as technology effectiveness, its cost (both per vehicle, per manufacturer, and per consumer), the lead time necessary to implement the technology, and based on this the feasibility and practicability of potential standards; the impacts of potential standards on emissions reductions of both GHGs and non-GHG emissions; the impacts of standards on oil conservation and energy security; the impacts of standards on fuel savings by customers; the impacts of standards on the truck industry; other energy impacts; as well as other relevant factors such as impacts on safety.

As part of the feasibility analysis of potential standards for HD pickups and vans, the agencies have applied DOT's ~~Corporate Average Fuel Economy (~~CAFE~~)~~ Compliance and Effects Modeling System (sometimes referred to as "the CAFE model" or "the Volpe model"), which DOT's Volpe National Transportation Systems Center (Volpe Center) developed, maintains, and applies to support NHTSA CAFE analyses and rulemakings. The agencies used this model to determine the range of stringencies that might be achievable through the use of technology that is projected to be available in the Phase 2 time frame. From these runs, the agencies identified the stringency level that would be technology-forcing, but leave manufacturers the flexibility to adopt varying technology paths for compliance.

The proposed phase-in schedule of reduction of 2.75% per year in fuel consumption and CO_2 levels relative to the final Phase 1 standard level, starting in 2021 and extending through 2025~~,~~ was chosen to strike a balance between meaningful reductions in the early years and providing manufacturers with needed lead time via a gradually accelerating ramp-up of technology penetration. By expressing the phase-in in terms of increasing year to year

[15] 49 USC 32902(k)(2).

stringency for each manufacturer, while also providing for credit generation and use (including averaging, carry-forward, and carry-back), we believe our program affords manufacturers substantial flexibility to satisfy the proposed phase-in through a variety of pathways: the gradual application of technologies across the fleet, greater application levels on only a portion of the fleet, and a sufficiently broad set of available technologies to account for the variety of current technology deployment among manufacturers and the lowest-cost compliance paths available to each~~.~~.

We decided that a phased implementation schedule would be appropriate to accommodate manufacturers' redesign workload and product schedules, especially in light of this sector's limited product offerings[16] and long product cycles. We did not estimate the cost of implementing the ~~final~~proposed standards immediately in 2021 without a phase-in, but we qualitatively assessed it to be ~~much~~somewhat higher than the cost of the phase-in we are proposing, due to the workload and product cycle disruptions it ~~would~~could cause, and also due to manufacturers' resulting need to develop some of these technologies for heavy-duty applications sooner than or simultaneously with light-duty development efforts. On the other hand, waiting until 2025 before applying any new standards could miss the opportunity to achieve meaningful and cost-effective early reductions not requiring a major product redesign when the largest changes and reductions are expected to occur.

We ~~considered setting~~are also considering more stringent standards that would require the application of additional technologies by 2025 (and broader application of the proposed technologies) and are requesting comment on Alternative 4 which is more stringent than the proposed Alternative 3a~~al~~. We expect, in fact, that some of these technologies may well prove feasible and cost-effective in this timeframe, and may even become technologies of choice for individual manufacturers. This dynamic has played out in rulemakings before and highlights the value of setting performance-based standards that leave engineers the freedom to find the most cost-effective solutions and not hinder consumer choice.

However, the agencies do not believe that at this stage there is enough information about the viability of some advanced technologies in this vehicle segment to assume that they can be a part of large-volume deployment strategies for regulated manufacturers~~.~~. For example, we believe that hybrid electric technology could provide significant GHG and fuel consumption benefits, but we recognize that there is uncertainty at this time over the real world effectiveness of these systems in heavy-duty applications, and over customer acceptance of vehicles with high GCWR towing large loads. Further, the development, design, and tooling effort needed to apply this technology to a vehicle model is quite large, and ~~seems less likely to~~could prove cost-effective due to the small sales volumes relative to the light-duty sector. Additionally, the smaller engines that facilitate much of a hybrid's benefit in the light-duty sector are typically at odds with the importance pickup trucks buyers place on engine horsepower and torque necessary to meet towing objectives.

[16] Manufacturers generally have only one pickup platform and one van platform in this segment.

We also considered ~~setting~~proposing less stringent standards~~,~~ under which manufacturers could comply by deploying a more limited set of technologies. However, our assessment concluded with a high degree of confidence that the technologies on which the ~~final~~proposed standards are premised would be available at reasonable cost in the 2021-2025 timeframe, and that the phase-in and other flexibility provisions allow for their application in a very cost-effective manner, as discussed in this section below.

More difficult to characterize is the degree to which more or less stringent standards might be appropriate because of under- or over-estimating the costs or effectiveness of the technologies whose performance is the basis of the ~~final~~proposed standards. For the most part, these technologies have not yet been applied to HD pickups and vans, even on a limited basis therefore we are relying to some degree on engineering judgment in predicting their effectiveness. Even so, we believe that we have applied this judgment using the best information available, primarily from a NHTSA contracted study at SwRI and our recent rulemaking on light-duty vehicle GHGs and fuel economy, and have generated a robust set of effectiveness values. The Draft RIA provides a detailed description of the CAFE Model and the analysis performed for the proposal.

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JW: citation forthcoming, though this should not be the first mention in the preamble.

(1) Regulatory Alternatives Considered by the Agencies

As discussed above, the agencies are proposing standards defined by fuel consumption and GHG targets that continue through model year 2020 unchanged from model year 2018, and then increase in stringency at an annual rate of 2.75% through model year 2025. In addition to this regulatory alternative, the agencies also considered a no-action alternative under which standards remain unchanged after model year 2018, as well as four other alternatives, defined by annual stringency increases of 2.0 percent, 2.75 percent, 3.5 percent, and 4.0 percent during 2021-2025. For each of the "action alternatives" (i.e., those involving stringency increases beyond the no-action alternative), the annual stringency increases are applied as follows: An annual stringency increase of r is applied by multiplying the model year 2020 target functions (identical to those applicable to model year 2018) by $1 - r$ to define the model year 2021 target functions, multiplying the model year 2021 target functions by $1 - r$ to define the model year 2022 target functions, continuing through 2025. In summary, the agencies have considered the following five regulatory alternatives:

Regulatory Alternative	Annual Stringency Increase	
	2019-2020	2021-2025
1: No Action	None	None
2: 2.0%/y	None	2.0%
3: 2.75%/y	None	2.75%
4: 3.5%/y	None	3.5%
5: 4.0%/y	None	4.0%

(2) DOT CAFE Model

DOT developed the CAFE model in 2002 to support the 2003 issuance of CAFE standards for MYs 2005-2007 light trucks. DOT has since significantly expanded and refined the model, and has applied the model to support every ensuing CAFE rulemaking for both light-duty and heavy-duty. For this analysis, the model was reconfigured to use the work based attribute metric of "work factor" established in the Phase 1 rule instead of the light duty "footprint" attribute metric.

Although the CAFE model can also be used for more aggregated analysis (e.g., involving "representative vehicles", single-year snapshots, etc.), NHTSA designed the model with a view toward (a) detailed simulation of manufacturers' potential actions given a defined set of standards, followed by (b) calculation of resultant impacts and economic costs and benefits. The model is intended to describe actions manufacturers could take in light of defined standards and other input assumptions and estimates, not to predict actions manufacturers will take in light of competing product and market interests (e.g. engine power, customer features, technology acceptance, etc.).

As a starting point, the model makes use of an input file defining the analysis fleet—that is, a set of specific vehicle models (e.g., Ford F250) and model configurations (e.g., Ford F250 with 6.2-liter V8 engine, 4WD, and 6-speed manual transmission) estimated or assumed to be produced by each manufacturer in each model year to be included in the analysis. The analysis fleet includes key engineering attributes (e.g., curb weight, payload and towing capacities, dimensions, presence of various fuel-saving technologies) of each vehicle model, engine, and transmissions, along with estimates or assumptions of future production volumes. It also specifies the extent to which specific vehicle models share engines, transmissions, and vehicle platforms, and describes each manufacturer's estimated or assumed product cadence (*i.e.*, timing for freshening and redesigning different vehicles and platforms). This input file also specifies a payback period used to estimate the potential that each manufacturer might apply technology to improve fuel economy beyond levels required by standards. The file used for this analysis was created from 2014 manufacturer compliance reports for the base sales and technology information, and a future fleet projection created from a combination of data from a sales forecast that the agencies purchased from IHS Automotive and total volumes class 2b and 3 fleet volumes from 2014 AEO Reference Case. A complete description of the future fleet is available in Draft RIA Section 2.14.

A second input file to the model contains a variety of contextual estimates and assumptions. Some of these inputs, such as future fuel prices and vehicle survival and mileage accumulation (versus vehicle age), are relevant to estimating manufacturers' potential application of fuel-saving technologies. Some others, such as fuel density and carbon content, vehicular and upstream emission factors, the social cost of carbon dioxide emissions, and the discount rate, are relevant to calculating physical and economic impacts of manufacturers' application of fuel-saving technologies.

A third input file contains estimates and assumptions regarding the future applicability, availability, efficacy, and cost of various fuel-saving technologies. Efficacy is expressed in terms of the percentage reduction in fuel consumption, cost is expressed in dollars, and both efficacy and cost are expressed on an incremental basis (i.e., estimates for more advanced technologies are specified as increments beyond less advanced technologies). The input file also includes "synergy factors" used to make adjustments accounting for the potential that some combinations of technologies may result fuel savings or costs different from those indicated by incremental values.

Finally, a fourth model input file specifies standards to be evaluated. Standards are defined on a year-by-year basis separately for each regulatory class (passenger cars, light trucks, and heavy-duty pickups and vans). Regulatory alternatives are specified as discrete scenarios, with one scenario defining the no-action alternative or "baseline", all other scenarios defining regulatory alternatives to be evaluated relative to that no-action alternative.

Given these inputs, the model estimates each manufacturer's potential year-by-year application of fuel-saving technologies to each engine, transmission, and vehicle. Subject to a range of engineering and planning-related constraints (e.g., secondary axle disconnect can't be applied to 2-wheel drive vehicles, many major technologies can only be applied practicably as part of a vehicle redesign, and applied technologies carry forward between model years), the model attempts to apply technology to each manufacturers' fleet in a manner that minimizes "effective costs" (accounting, in particular, for technology costs and avoided fuel outlays), continuing to add improvements as long as doing so would help toward compliance with specified standards or would produce fuel savings that "pay back" at least as quickly as specified in the input file mentioned above.

After estimating the extent to which each manufacturer might add fuel-saving technologies under each specified regulatory alternative, the model calculates a range of physical impacts, such as changes in highway travel (i.e., VMT), changes in fleetwide fuel consumption, changes in highway fatalities, and changes in vehicular and upstream greenhouse gas and criteria pollutant emissions. The model also applies a variety of input estimates and assumptions to calculate economic costs and benefits to vehicle owners and society, based on these physical impacts.

Since the manufacturers of HD pickups and vans generally only have one basic pick-up truck and van with different versions ((*i.e.*, different wheel bases, cab sizes, two-wheel drive, four-wheel drive, etc.) and do not have the flexibility of the light-duty fleet to coordinate model improvements over several years, changes to the HD pickups and vans to meet new standards must be carefully planned with the redesign cycle taken into account. The opportunities for large-scale changes (*e.g.*, new engines, transmission, vehicle body and mass) thus occur less frequently than in the light-duty fleet, typically at spans of 8 or more years. However, opportunities for gradual improvements not necessarily linked to large scale changes can occur between the redesign cycles. Examples of such improvements are upgrades to an existing vehicle model's engine, transmission and aftertreatment systems. Given this long redesign cycle and our understanding with respect to where the different manufacturers are in that cycle, the agencies have initially determined that the full implementation of the proposed standards would be feasible and appropriate by the 2025 model year.

This analysis reflects several changes made to the model since 2012, when NHTSA used the model to estimate the effects, costs, and benefits of final CAFE standards for light-duty vehicles produced during MYs 2017-2021, and augural standards for MYs 2022-2025. Some of these changes specifically enable analysis of potential fuel consumption standards (and, hence, CO_2 emissions standards harmonized with fuel consumption standards) for heavy-duty pickups and vans; other changes implement more general improvements to the model. Key changes include the following:

- Changes to accommodate standards for heavy-duty pickups and vans, including attribute-based standards involving targets that vary with "work factor".

- Explicit calculation of test weight, taking into account test weight "bins" and differences in the definition of test weight for light-duty vehicles (curb weight plus 300 pound) and heavy-duty pickups and vans (average of GVWR and curb weight).

- Procedures to estimate increases in payload when curb weight is reduced, increases in towing capacity if GVWR is reduced, and calculation procedures to correspondingly update calculated work factors.

- Inclusion of technologies not included in prior analyses.

- Changes to enable more explicit accounting for shared vehicle platforms and adoption and "inheritance" of major engine changes.

- Expansion of the Monte Carlo simulation procedures used to perform probabilistic uncertainty analysis.

In addition to the inputs summarized above, the agencies' analysis of potential standards for HD pickups and vans makes use of a range of other estimates and assumptions specified as inputs to the CAFE modeling system. Some significant inputs (e.g., estimates of future fuel prices) also applicable to other MDHD segments are discussed below in Section IX. Others more specific to the analysis of HD pickups and vans are listed as follows, with additional details in section D:

- Vehicle survival and mileage accumulation
- VMT rebound
- On-road "gap" in fuel consumption
- Fleet population profile
- Past fuel consumption levels
- Long-term fuel consumption levels
- Payback period
- Coefficients for fatality calculations
- Compliance credits carried-forward
- Emission factors for non-CO_2 emissions
- Refueling time benefits
- External Costs of travel
- Ownership and operating costs

The CAFE model and its modifications for this rulemaking are described in more detail in Section D below as well as the draft RIA.

(3) How Did the Agencies Develop the Analysis Fleet~~?~~

In order to estimate the impacts of potential standards, it is necessary to estimate the composition of the future vehicle fleet. Doing so enables estimation of the extent to which each manufacturer may need to add technology in response to a given series of attribute-based standards, accounting for the mix and fuel consumption of vehicles in each manufacturer's regulated fleet. The agencies create an analysis fleet in order to track the volumes and types of fuel economy-improving and CO2-reducing technologies that are already present in the existing vehicle fleet. This aspect of the analysis fleet helps to keep the CAFE model from adding technologies to vehicles that already have these technologies, which would result in "double counting" of technologies' costs and benefits. An additional step involved projecting the fleet sales into MYs 2019-2030. This represents the fleet volumes that the agencies believe would exist in MYs 2019-2030.

Most of the information about the vehicles that make up the 2014 analysis fleet was gathered from the 2014 Pre-Model Year Reports submitted to EPA by the manufacturers under Phase 1 of Fuel Efficiency and GHG Emission Program for Medium- and Heavy-Duty Trucks, MYs 2014-2018. The major manufacturers of class 2b and class 3 trucks (Chrysler, Ford and GM) were asked to voluntarily submit updates to their Pre-Model Year Reports. Updated data were provided by Chrysler and GM. These updated data were used in constructing the analysis fleet for these manufacturers. The agencies agreed to treat this information as Confidential Business Information (CBI) until the publication of the NPRM. This information can be made public at this time because by now all MY2014 vehicle models have been produced, which makes data about them essentially public information.

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In addition to information about each vehicle, the agencies need additional information about the fuel economy-improving/CO_2-reducing technologies already on those vehicles in order to assess how much and which technologies to apply to determine a path toward future compliance. Thus, the agencies augmented this information with publicly-available data that includes more complete technology descriptions, e.g. for specific engines and transmissions.

The analysis fleet also requires projections of sales volumes for the years of the rulemaking analysis. The agencies relied on the MY 2014 pre-model-year compliance submissions from manufacturers to provide sales volumes at the model level based on the level of disaggregation in which the models appear in the compliance data. However, the agencies only use these reported volumes without adjustment for MY 2014. For all future model years, we combine the manufacturer submissions with sales projections from the 2014 Annual Energy Outlook Reference Case and IHS Automotive to determine model variant level sales volumes in future years.[17]

For more detail on how the analysis fleet and sales volume projections were developed, please see Section D below as well as the draft RIA.

(4) What Technologies Did the Agencies Consider~~?~~

The agencies considered over 35 vehicle technologies that manufacturers could use to improve the fuel consumption and reduce CO_2 emissions of their vehicles during MYs 2021-2025. The majority of the technologies described in this section is readily available, well known and proven in other vehicle sectors, and could be incorporated into vehicles once production decisions are made. Other technologies considered may not currently be in production, but are beyond the research phase and under development, and are expected to be in production in highway vehicles over the next few years. These are technologies that~~which~~ are capable of achieving significant improvements in fuel economy and reductions in CO_2 emissions, at reasonable costs. The agencies did not consider technologies in the research stage because there is insufficient time for such technologies to move from research to production during the model years covered by this ~~final~~proposed action. However, we are considering and seek comment on advanced technology credits to encourage the development of new ideas, as discussed below in Section VI.D.

The technologies considered in the agencies' analysis are briefly described below. They fall into five broad categories: engine technologies, transmission technologies, vehicle technologies, electrification/accessory technologies, and hybrid technologies.

In this class of trucks and vans, diesel engines are installed in about half of all vehicles. The buyer's decision to purchase a diesel versus gasoline engine depends on several factors including initial purchase price, fuel operating costs, durability, towing capability and payload capacity amongst other reasons. In the context of our technology discussion for heavy-duty pickups and vans, we are treating gasoline and diesel engines separately so each has a set of baseline technologies. We discuss performance improvements in terms of changes to those baseline engines. Our cost and inventory estimates contained elsewhere reflect the current fleet baseline with an appropriate mix of gasoline and diesel engines. Note that we are not basing the proposed standards on a targeted switch in the mix of diesel and gasoline vehicles. We believe our proposed standards require similar levels of technology development and cost for both diesel and gasoline vehicles. Hence the proposed program does not force, nor does it discourage, changes in a manufacturer's fleet mix between gasoline and diesel vehicles. Types of engine technologies that improve fuel efficiency and reduce CO_2 emissions include the following:

- *Low-friction lubricants* – low viscosity and advanced low friction lubricants oils are now available with improved performance and better lubrication. If manufacturers choose to make use of these lubricants, they would need to make engine changes and possibly conduct durability testing to accommodate the low-friction lubricants.

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- *Reduction of engine friction losses* – can be achieved through low-tension piston rings, roller cam followers, improved material coatings, more optimal thermal management, piston surface treatments, and other improvements in the design of engine components and subsystems that improve engine operation.

- *Reduction of engine parasitic demand* – mechanical engine load reduction can be achieved by variable-displacement oil pumps, higher-efficiency direct injection fuel pumps, and variable speed/displacement coolant pumps.

- *Cylinder deactivation* – deactivates the intake and exhaust valves and prevents fuel injection into some cylinders during light-load operation. The engine runs temporarily as though it were a smaller engine which substantially reduces pumping losses.

- *Variable valve timing* – alters the timing of the intake valve, exhaust valve, or both, primarily to reduce pumping losses, increase specific power, and control residual gases.

- *Variable valve lift* – alters the intake valve lift in order to reduce pumping losses and more efficiently ingest air.

- *Stoichiometric gasoline direct-injection technology* – injects fuel at high pressure directly into the combustion chamber to improve cooling of the air/fuel charge within the cylinder, which allows for higher compression ratios and increased thermodynamic efficiency.

- ~~•~~ *Cooled exhaust gas recirculation* – concept that involves utilizing EGR as a charge diluent for controlling combustion temperatures and cooling the EGR prior to its introduction to the combustion system.

- *Turbocharging and downsizing* – light duty concept that involves decreasing the displacement and cylinder count to improve efficiency when not demanding regular high loads and adding a turbocharger to recover any loss to the original larger engine peak operating power. This technology was limited in this analysis to vehicles that are not expected to operate at high trailer towing levels and instead are more akin to duty cycles of light duty (i.e. V6 vans).

- *Lean-burn combustion* – concept that gasoline engines that are normally stoichiometric mainly for emission reason can run lean and utilize some diesel like aftertreatment to control NOx. For this analysis, we determined that the modal operation nature of this technology to currently only be beneficial at light loads would not be appropriate for a heavy duty application purchased specifically for its high work and load capability.

- *Diesel engine improvements and diesel aftertreatment improvements* – improved turbocharger, EGR systems, and advanced timing can provide more efficient combustion and, hence, lower fuel consumption. Aftertreatment systems are a relatively new technology on diesel vehicles and, as such, improvements are expected in coming years that allow the effectiveness of these systems to improve while reducing the fuel and reductant demands of current systems.

Types of transmission technologies considered include:

- *Eight-speed automatic transmissions* – the gear span, gear ratios, and control system are optimized for a broader range of efficient engine operating conditions.

- *High efficiency transmission* – significant reduction of internal parasitic losses such as pumps gear bands, etc.

- *Driveline friction reduction* – reduction in the driveline friction from improvements to bearings, seals and other machining tolerances in the axles and transfer cases.

- *Secondary axle disconnect* – disconnecting of some rotating components in the front axle on 4wd vehicles when the secondary axle is not needed for traction.

Types of vehicle technologies considered include:

- *Low-rolling-resistance tires* – have characteristics that reduce frictional losses associated with the energy dissipated in the deformation of the tires under load, therefore improving fuel efficiency and reducing CO_2 emissions.

- *Aerodynamic drag reduction* – is achieved by changing vehicle shape or reducing frontal area, including skirts, air dams, underbody covers, and more aerodynamic side view mirrors.

- *Mass reduction and material substitution* – Mass reduction encompasses a variety of techniques ranging from improved design and better component integration to application of lighter and higher-strength materials. Mass reduction is further compounded by reductions in engine power and ancillary systems (transmission, steering, brakes, suspension, etc.). The agencies recognize there is a range of diversity and complexity for mass reduction and material substitution technologies and there are many techniques that automotive suppliers and manufacturers are using to achieve the levels of this technology that the agencies have modeled in our analysis for this program.

Types of electrification/accessory and hybrid technologies considered include:

- *Electric power steering* – are electrically-assisted steering systems that have advantages over traditional hydraulic power steering because it replaces a continuously operated hydraulic pump, thereby reducing parasitic losses from the accessory drive.

- *Improved accessories* – may include high efficiency alternators, electrically driven (i.e., on-demand) water pumps and cooling fans. This excludes other electrical accessories such as electric oil pumps and electrically driven air conditioner compressors.

- *Mild hybrid* – a small, engine-driven (through a belt or other mechanism) electric motor/generator/battery combination to enable features such as start-stop, energy recovery, and launch assist.

- *Strong hybrid* – a powerful electric motor/generator/battery system coupled to the powertrain to enable features such as start-stop, and significant levels of launch assist, electric operation, and brake energy recovery. For HD pickups and vans, the engine coupled with the strong hybrid system would remain unchanged in power and torque to ensure vehicle performance at all times, even if the hybrid battery is depleted.

- *Air Conditioner Systems* – These technologies include improved hoses, connectors and seals for leakage control. They also include improved compressors, expansion valves, heat exchangers and the control of these components for the purposes of improving tailpipe CO_2 emissions as a result of A/C use.[18]

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[18] *See* RIA Chapter 2.3 for more detailed technology descriptions.

(5) How Did the Agencies Determine the Costs and Effectiveness of Each of These Technologies~~?~~

Building on the technical analysis underlying the 2017-2025 MY light-duty vehicle rule, the 2014-2018 MY heavy-duty vehicle rule, and the 2014 SwRI report, the agencies took a fresh look at technology cost and effectiveness values for purposes of this proposal. For costs, the agencies reconsidered both the direct (or "piece") costs and indirect costs of individual components of technologies. For the direct costs, the agencies followed a bill of materials (BOM) approach employed by the agencies in the light-duty rule as well as referencing costs from the 2014-2018 MY heavy-duty vehicle rule and a new cost survey performed by Tetra Tech in 2014.

For two technologies, stoichiometric gasoline direct injection (SGDI) and turbocharging with engine downsizing, the agencies relied to the extent possible on the available tear-down data and scaling methodologies used in EPA's ongoing study with FEV, Incorporated. This study consists of complete system tear-down to evaluate technologies down to the nuts and bolts to arrive at very detailed estimates of the costs associated with manufacturing them.[19]

For the other technologies, considering all sources of information and using the BOM approach, the agencies worked together intensively to determine component costs for each of the technologies and build up the costs accordingly. Where estimates differ between sources, we have used engineering judgment to arrive at what we believe to be the best cost estimate available today, and explained the basis for that exercise of judgment.

Once costs were determined, they were adjusted to ensure that they were all expressed in 2012 dollars (see Section IX.B.1.e of this preamble), and indirect costs were accounted for using a methodology consistent with the new ICM approach developed by EPA and used in the Phase 1 rule, and the 2012-2016 and 2017-2025 light-duty rules. NHTSA and EPA also reconsidered how costs should be adjusted by modifying or scaling content assumptions to account for differences across the range of vehicle sizes and functional requirements, and adjusted the associated material cost impacts to account for the revised content. We present the individual technology costs used in this analysis in Chapter 2.12 of the Draft RIA.

Regarding estimates for technology effectiveness, the agencies used the estimates from the 2014 Southwest Research Institute study as a baseline, which was designed specifically to inform this rulemaking. In addition, the agencies used 2017-2025 light-duty rule as a reference, and adjusted these estimates as appropriate, taking into account the unique requirement of the heavy-duty test cycles to test at curb weight plus half payload versus the light-duty requirement of curb plus 300 lb. The adjustments were made on an individual technology basis by assessing the specific impact of the added load on each technology when compared to the use of the

[19] U.S. Environmental Protection Agency, "Draft Report – Light-Duty Technology Cost Analysis Pilot Study," Contract No. EP-C-07-069, Work Assignment 1-3, September 3, 2009.

technology on a light-duty vehicle. The agencies also considered other sources such as the 2010 NAS Report, recent CAFE compliance data, and confidential manufacturer estimates of technology effectiveness. The agencies reviewed effectiveness information from the multiple sources for each technology and ensured that such effectiveness estimates were based on technology hardware consistent with the BOM components used to estimate costs. Together, the agencies compared the multiple estimates and assessed their validity, taking care to ensure that common BOM definitions and other vehicle attributes such as performance and drivability were taken into account.

The agencies note that the effectiveness values estimated for the technologies may represent average values applied to the baseline fleet described earlier, and do not reflect the potentially-limitless spectrum of possible values that could result from adding the technology to different vehicles. For example, while the agencies have estimated an effectiveness of 0.5 percent for low friction lubricants, each vehicle could have a unique effectiveness estimate depending on the baseline vehicle's oil viscosity rating. Similarly, the reduction in rolling resistance (and thus the improvement in fuel efficiency and the reduction in CO_2 emissions) due to the application of LRR tires depends not only on the unique characteristics of the tires originally on the vehicle, but on the unique characteristics of the tires being applied, characteristics which must be balanced between fuel efficiency, safety, and performance. Aerodynamic drag reduction is much the same—it can improve fuel efficiency and reduce CO_2 emissions, but it is also highly dependent on vehicle-specific functional objectives. For purposes of this NPRM, the agencies believe that employing average values for technology effectiveness estimates is an appropriate way of recognizing the potential variation in the specific benefits that individual manufacturers (and individual vehicles) might obtain from adding a fuel-saving technology.

The following contains a description of technologies the agencies considered in the analysis for this proposal.

(a) Engine Technologies

The agencies reviewed the engine technology estimates used in the 2017-2025 light-duty rule, the 2014-2018 heavy-duty rule, and the 2014 SwRI report. In doing so the agencies reconsidered all available sources and updated the estimates as appropriate. The section below describes both diesel and gasoline engine technologies considered for this program.

(i) *Low Friction Lubricants*

One of the most basic methods of reducing fuel consumption in both gasoline and diesel engines is the use of lower viscosity engine lubricants. More advanced multi-viscosity engine oils are available today with improved performance in a wider temperature band and with better lubricating properties. This can be accomplished by changes to the oil base stock (*e.g.*, switching engine lubricants from a Group I base oils to lower-friction, lower viscosity Group III synthetic) and through changes to lubricant additive packages (*e.g.*, friction modifiers and viscosity improvers). The use of 5W-30 motor oil is now widespread and auto manufacturers are introducing the use of even lower viscosity oils, such as 5W-20 and 0W-20, to improve cold-flow properties and reduce cold start friction. However, in some cases, changes to the crankshaft, rod and main bearings and changes to the mechanical tolerances of engine components may be required. In all cases, durability testing would be required to ensure that durability is not compromised. The shift to lower viscosity and lower friction lubricants will also improve the effectiveness of valvetrain technologies such as cylinder deactivation, which rely on a minimum oil temperature (viscosity) for operation.

(ii) Engine Friction Reduction

In addition to low friction lubricants, manufacturers can also reduce friction and improve fuel consumption by improving the design of both diesel and gasoline engine components and subsystems. Approximately 10 percent of the energy consumed by a vehicle is lost to friction, and just over half is due to frictional losses within the engine.[20] Examples include improvements in low-tension piston rings, piston skirt design, roller cam followers, improved crankshaft design and bearings, material coatings, material substitution, more optimal thermal management, and piston and cylinder surface treatments. Additionally, as computer-aided modeling software continues to improve, more opportunities for evolutionary friction reductions may become available. All reciprocating and rotating components in the engine are potential candidates for friction reduction, and minute improvements in several components can add up to a measurable fuel efficiency improvement.

(iii) Engine Parasitic Demand Reduction

In addition to physical engine friction reduction, manufacturers can also reduce the mechanical load on the engine from parasitics, such as oil, fuel, and coolant pumps. The high-pressure fuel pumps of direct-injection gasoline and diesel engines have particularly high demand. Example improvements include variable speed or variable displacement water pumps, variable displacement oil pumps, more efficient high pressure fuel pumps, valve train upgrades and shutting off piston cooling when not needed.

(iv) Coupled Cam Phasing

Valvetrains with coupled (or coordinated) cam phasing can modify the timing of both the inlet valves and the exhaust valves an equal amount by phasing the camshaft of an overhead valve engine.[21] For overhead valve engines, which have only one camshaft to actuate both inlet

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[20] "Impact of Friction Reduction Technologies on Fuel Economy," Fenske, G. Presented at the March 2009 Chicago Chapter Meeting of the 'Society of Tribologists and Lubricated Engineers' Meeting, March 18th, 2009. Available at: http://www.chicagostle.org/program/2008-2009/Impact%20of%20Friction%20Reduction%20Technologies%20on%20Fuel%20Economy%20-%20with%20VGs%20removed.pdf (last accessed July 9, 2009).

[21] Although couple cam phasing appears only in the single overhead cam and overhead valve branches of the decision tree, it is noted that a single phaser with a secondary chain drive would allow couple cam phasing to be applied to direct overhead cam engines. Since this would potentially be adopted on a limited number of direct overhead cam engines NHTSA did not include it in that branch of the decision tree.

and exhaust valves, couple cam phasing is the only variable valve timing implementation option available and requires only one cam phaser.[22]

(v) Cylinder Deactivation

In conventional spark-ignited engines throttling the airflow controls engine torque output. At partial loads, efficiency can be improved by using cylinder deactivation instead of throttling. Cylinder deactivation can improve engine efficiency by disabling or deactivating (usually) half of the cylinders when the load is less than half of the engine's total torque capability – the valves are kept closed, and no fuel is injected – as a result, the trapped air within the deactivated cylinders is simply compressed and expanded as an air spring, with reduced friction and heat losses. The active cylinders combust at almost double the load required if all of the cylinders were operating. Pumping losses are significantly reduced as long as the engine is operated in this "part-cylinder" mode.

Cylinder deactivation control strategy relies on setting maximum manifold absolute pressures or predicted torque within a range in which it can deactivate the cylinders. Noise and vibration issues reduce the operating range to which cylinder deactivation is allowed, although manufacturers are exploring vehicle changes that enable increasing the amount of time that cylinder deactivation might be suitable. Some manufacturers may choose to adopt active engine mounts and/or active noise cancellations systems to address Noise Vibration and Harshness (NVH) concerns and to allow a greater operating range of activation.

Cylinder deactivation has seen a recent resurgence thanks to better valvetrain designs and engine controls. General Motors and Chrysler Group have incorporated cylinder deactivation across a substantial portion of their V8-powered lineups.

(vi) Stoichiometric Gasoline Direct Injection

SGDI engines inject fuel at high pressure directly into the combustion chamber (rather than the intake port in port fuel injection). SGDI requires changes to the injector design, an additional high pressure fuel pump, new fuel rails to handle the higher fuel pressures and changes to the cylinder head and piston crown design. Direct injection of the fuel into the cylinder improves cooling of the air/fuel charge within the cylinder, which allows for higher compression ratios and increased thermodynamic efficiency without the onset of combustion knock. Recent injector design advances, improved electronic engine management systems and the introduction of multiple injection events per cylinder firing cycle promote better mixing of the air and fuel, enhance combustion rates, increase residual exhaust gas tolerance and improve cold start emissions. SGDI engines achieve higher power density and match well with other technologies, such as boosting and variable valvetrain designs.

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[22] It is also noted that coaxial camshaft developments would allow other variable valve timing options to be applied to overhead valve engines. However, since they would potentially be adopted on a limited number of overhead valve engines, NHTSA did not include them in the decision tree.

Several manufacturers have recently introduced vehicles with SGDI engines, including GM and Ford and have announced their plans to increase dramatically the number of SGDI engines in their portfolios.

(vii) Turbocharging and Downsizing

The specific power of a naturally aspirated engine is primarily limited by the rate at which the engine is able to draw air into the combustion chambers. Turbocharging and supercharging (grouped together here as boosting) are two methods to increase the intake manifold pressure and cylinder charge-air mass above naturally aspirated levels. Boosting increases the airflow into the engine, thus increasing the specific power level, and with it the ability to reduce engine displacement while maintaining performance. This effectively reduces the pumping losses at lighter loads in comparison to a larger, naturally aspirated engine.

Almost every major manufacturer currently markets a vehicle with some form of boosting. While boosting has been a common practice for increasing performance for several decades, turbocharging has considerable potential to improve fuel economy and reduce CO2 emissions when the engine displacement is also reduced. Specific power levels for a boosted engine often exceed 100 hp/L, compared to average naturally aspirated engine power densities of roughly 70 hp/L. As a result, engines can be downsized roughly 30 percent or higher while maintaining similar peak output levels. In the last decade, improvements to turbocharger turbine and compressor design have improved their reliability and performance across the entire engine operating range. New variable geometry turbines and ball-bearing center cartridges allow faster turbocharger spool-up (virtually eliminating the once-common "turbo lag") while maintaining high flow rates for increased boost at high engine speeds. Low speed torque output has been dramatically improved for modern turbocharged engines. However, even with turbocharger improvements, maximum engine torque at very low engine speed conditions, for example launch from standstill, is increased less than at mid and high engine speed conditions. The potential to downsize engines may be less on vehicles with low displacement to vehicle mass ratios for example a very small displacement engine in a vehicle with significant curb weight, in order to provide adequate acceleration from standstill, particularly up grades or at high altitudes.

Use of GDI systems with turbocharged engines and air-to-air charge air cooling also reduces the fuel octane requirements for knock limited combustion and allows the use of higher compression ratios. Ford's "Ecoboost" downsized, turbocharged GDI engines introduced on MY 2010 vehicles allow the replacement of V8 engines with V6 engines with improved in 0-60 mph acceleration and with fuel economy improvements of up to 12 percent.

Recently published data with advanced spray-guided injection systems and more aggressive engine downsizing targeted towards reduced fuel consumption and CO2 emissions reductions indicate that the potential for reducing CO2 emissions for turbocharged, downsized GDI engines may be as much as 15 to 30 percent relative to port-fuel-injected engines.[14,15,16,17,18] Confidential manufacturer data suggests an incremental range of fuel consumption and CO2 emission reduction of 4.8 to 7.5 percent for turbocharging and downsizing. Other publicly-available sources suggest a fuel consumption and CO2 emission reduction of 8 to 13 percent compared to current-production naturally-aspirated engines without friction reduction or other fuel economy technologies: a joint technical paper by Bosch and Ricardo suggesting fuel economy gain of 8 to 10 percent for downsizing from a 5.7 liter port injection V8 to a 3.6 liter V6 with direct injection using a wall-guided direct injection system; a Renault report suggesting a 11.9 percent NEDC fuel consumption gain for downsizing from a 1.4 liter port injection in-line 4-cylinder engine to a 1.0 liter in-line 4-cylinder engine, also with wall-guided direct injection; and a Robert Bosch paper suggesting a 13 percent NEDC gain for downsizing to a turbocharged DI engine, again with wall-guided injection. These reported fuel economy benefits show a wide range depending on the SGDI technology employed.

Note that for this analysis we determined that this technology path is only applicable to heavy duty applications that have operating conditions more closely associated with light duty vehicles. This includes vans designed mainly for cargo volume or modest payloads having similar GCWR to light duty applications. These vans cannot tow trailers heavier than similar light duty vehicles and are largely already sharing engines of significantly smaller displacement and cylinder count compared to heavy duty vehicles designed mainly for trailer towing.

(viii) Cooled Exhaust-Gas Recirculation

Cooled exhaust gas recirculation or Boosted EGR is a combustion concept that involves utilizing EGR as a charge diluent for controlling combustion temperatures and cooling the EGR prior to its introduction to the combustion system. Higher exhaust gas residual levels at part load conditions reduce pumping losses for increased fuel economy. The additional charge dilution enabled by cooled EGR reduces the incidence of knocking combustion and obviates the need for fuel enrichment at high engine power. This allows for higher boost pressure and/or compression ratio and further reduction in engine displacement and both pumping and friction losses while maintaining performance. Engines of this type use GDI and both dual cam phasing and discrete variable valve lift. The EGR systems considered in this ~~final~~proposed rule, consistent with the proposal, would use a dual-loop system with both high and low pressure EGR loops and dual EGR coolers. The engines would also use single-stage, variable geometry turbocharging with higher intake boost pressure available across a broader range of engine operation than conventional turbocharged SI engines. Such a system is estimated to be capable of an additional 3 to 5 percent effectiveness relative to a turbocharged, downsized GDI engine without cooled-EGR. The agencies have also considered a more advanced version of such a cooled EGR system that employs very high combustion pressures by using dual stage turbocharging.

(b) Diesel Engine Technologies

Diesel engines have several characteristics that give them superior fuel efficiency compared to conventional gasoline, spark-ignited engines. Pumping losses are much lower due to lack of (or greatly reduced) throttling. The diesel combustion cycle operates at a higher compression ratio, with a very lean air/fuel mixture, and turbocharged light-duty diesels typically achieve much higher torque levels at lower engine speeds than equivalent-displacement naturally-aspirated gasoline engines. Additionally, diesel fuel has a higher energy content per gallon.[23] However, diesel fuel also has a higher carbon to hydrogen ratio, which increases the amount of CO_2 emitted per gallon of fuel used by approximately 15 percent over a gallon of gasoline.

Based on confidential business information and the 2010 NAS Report, two major areas of diesel engine design will be improved during the 2021-2025 timeframe. These areas include aftertreatment improvements and a broad range of engine improvements.

(i) Aftertreatment Improvements

The HD diesel pickup and van segment has largely adopted the SCR type of aftertreatment system to comply with criteria pollutant emission standards. As the experience base for SCR expands over the next few years, many improvements in this aftertreatment system such as construction of the catalyst, thermal management, and reductant optimization may result in a reduction in the amount of fuel used in the process. However, due to uncertainties with these improvements regarding the extent of current optimization and future criteria emissions obligations, the agencies are not considering aftertreatment improvements as a fuel-saving technology in the rulemaking analysis.

(ii) Engine Improvements

Diesel engines in the HD pickup and van segment are expected to have several improvements in their base design in the 2021-2025 timeframe. These improvements include items such as improved combustion management, optimal turbocharger design, and improved thermal management.

(c) Transmission Technologies

The agencies have also reviewed the transmission technology estimates used in the 2017-2015 light-duty and 2014-2018 heavy-duty final rules. In doing so, NHTSA and EPA considered or reconsidered all available sources including the 2014 SwRI report and updated the estimates as appropriate. The section below describes each of the transmission technologies considered for the proposal.

(i) Automatic 8-Speed Transmissions

Manufacturers can also choose to replace 6-speed automatic transmissions with 8-speed automatic transmissions. Additional ratios allow for further optimization of engine operation over a wider range of conditions, but this is subject to diminishing returns as the number of speeds increases. As additional gear sets are added, additional weight and friction are introduced requiring additional countermeasures to offset these losses. Some manufacturers are replacing 6-speed automatics already, and 7- and 8-speed automatics have entered production.

[23] Burning one gallon of diesel fuel produces about 15 percent more carbon dioxide than gasoline due to the higher density and carbon to hydrogen ratio.

(ii) High Efficiency Transmission

For this proposal, a high efficiency transmission refers to some or all of a suite of incremental transmission improvement technologies that should be available within the 2019 to 2025 timeframe. The majority of these improvements address mechanical friction within the transmission. These improvements include but are not limited to: shifting clutch technology improvements, improved kinematic design, dry sump lubrication systems, more efficient seals, bearings and clutches (reducing drag), component superfinishing and improved transmission lubricants.

(d) Electrification/Accessory Technologies

(i) Electrical Power Steering or Electrohydraulic Power Steering

Electric power steering (EPS) or Electrohydraulic power steering (EHPS) provides a potential reduction in CO_2 emissions and fuel consumption over hydraulic power steering because of reduced overall accessory loads. This eliminates the parasitic losses associated with belt-driven power steering pumps which consistently draw load from the engine to pump hydraulic fluid through the steering actuation systems even when the wheels are not being turned. EPS is an enabler for all vehicle hybridization technologies since it provides power steering when the engine is off. EPS may be implemented on most vehicles with a standard 12V system. Some heavier vehicles may require a higher voltage system which may add cost and complexity.

(ii) Improved Accessories

The accessories on an engine, including the alternator, coolant and oil pumps are traditionally mechanically-driven. A reduction in CO_2 emissions and fuel consumption can be realized by driving them electrically, and only when needed ("on-demand").

Electric water pumps and electric fans can provide better control of engine cooling. For example, coolant flow from an electric water pump can be reduced and the radiator fan can be shut off during engine warm-up or cold ambient temperature conditions which will reduce warm-up time, reduce warm-up fuel enrichment, and reduce parasitic losses.

Indirect benefit may be obtained by reducing the flow from the water pump electrically during the engine warm-up period, allowing the engine to heat more rapidly and thereby reducing the fuel enrichment needed during cold operation and warm-up of the engine. Faster oil warm-up may also result from better management of the coolant warm-up period. Further benefit may be obtained when electrification is combined with an improved, higher efficiency engine alternator used to supply power to the electrified accessories.

Intelligent cooling can more easily be applied to vehicles that do not typically carry heavy payloads, so larger vehicles with towing capacity present a challenge, as these vehicles have high cooling fan loads.[24] However, towing vehicles tend to have large cooling system capacity and flow scaled to required heat rejection levels when under full load situations such as towing at GCWR in extreme ambient conditions. During almost all other situations, this design characteristic may result in unnecessary energy usage for coolant pumping and heat rejection to the radiator.

The agencies considered whether to include electric oil pump technology for the rulemaking. Because it is necessary to operate the oil pump any time the engine is running, electric oil pump technology has insignificant effect on efficiency. Therefore, the agencies decided to not include electric oil pump technology.

(iii) Mild Hybrid

Mild hybrid systems offer idle-stop functionality and a limited level of regenerative braking and power assist. These systems replace the conventional alternator with a belt or crank driven starter/alternator and may add high voltage electrical accessories (which may include electric power steering and an auxiliary automatic transmission pump). The limited electrical requirements of these systems allow the use of lead-acid batteries or supercapacitors for energy storage, or the use of a small lithium-ion battery pack.

(iv) Strong Hybrid

A hybrid vehicle is a vehicle that combines two significant sources of propulsion energy, where one uses a consumable fuel (like gasoline), and one is rechargeable (during operation, or by another energy source). Hybrid technology is well established in the U.S. market and more manufacturers are adding hybrid models to their lineups. Hybrids reduce fuel consumption through three major mechanisms:

- The internal combustion engine can be optimized (through downsizing, modifying the operating cycle, or other control techniques) to operate at or near its most efficient point more of the time. Power loss from engine downsizing can be mitigated by employing power assist from the secondary power source.
- A significant amount of the energy normally lost as heat while braking can be captured and stored in the energy storage system for later use.
- The engine is turned off when it is not needed, such as when the vehicle is coasting or when stopped.

Hybrid vehicles utilize some combination of the three above mechanisms to reduce fuel consumption and CO_2 emissions. The effectiveness of fuel consumption and CO_2

[24] In the CAFE model, improved accessories refers solely to improved engine cooling. However, EPA has included a high efficiency alternator in this category, as well as improvements to the cooling system.

reduction depends on the utilization of the above mechanisms and how aggressively they are pursued. One area where this variation is particularly prevalent is in the choice of engine size and its effect on balancing fuel economy and performance. Some manufacturers choose not to downsize the engine when applying hybrid technologies. In these cases, overall performance is typically improved beyond the conventional engine, however fuel efficiency improves less than if the engine was downsized to maintain the same performance as the conventional version. The non-downsizing approach is used for vehicles like trucks where towing and/or hauling are an integral part of their performance requirements. In these cases, if the engine is downsized, the battery can be quickly drained during a long hill climb with a heavy load, leaving only a downsized engine to carry the entire load. Because towing capability is currently a heavily-marketed truck attribute, manufacturers are hesitant to offer a truck with downsized engine which can lead to a significantly diminished towing performance when the battery state of charge level is low, and therefore engines are traditionally not downsized for these vehicles. Strong Hybrid technology utilizes an axial electric motor connected to the transmission input shaft and connected to the engine crankshaft through a clutch. The axial motor is a motor/generator that can provide sufficient torque for launch assist, all electric operation, and the ability to recover significant levels of braking energy.

(e) Vehicle Technologies

(i) Mass Reduction

Reducing a vehicle's mass, or down-weighting the vehicle, decreases fuel consumption by reducing the energy demand needed to overcome forces resisting motion, and rolling resistance. Manufacturers employ a systematic approach to mass reduction, where the net mass reduction is the addition of a direct component or system mass reduction plus the additional mass reduction taken from indirect ancillary systems and components, as a result of full vehicle optimization, effectively compounding or obtaining a secondary mass reduction from a primary mass reduction. For example, use of a smaller, lighter engine with lower torque-output subsequently allows the use of a smaller, lighter-weight transmission and drive line components. Likewise, the compounded weight reductions of the body, engine and drivetrain reduce stresses on the suspension components, steering components, wheels, tires and brakes, allowing further reductions in the mass of these subsystems. The reductions in unsprung masses such as brakes, control arms, wheels and tires further reduce stresses in the suspension mounting points. This produces a compounding effect of mass reductions. However, the levels of compounding that are prevalent in light-duty vehicles may not be as viable for heavy-duty vehicles due to the payload and towing requirements.

Estimates of the synergistic effects of mass reduction and the compounding effect that occurs along with it can vary significantly from one report to another. For example, in discussing its estimate, an Auto-Steel Partnership report states that "These secondary mass changes can be considerable—estimated at an additional 0.7 to 1.8 times the initial mass change."[25] This means for each one pound reduction in a primary component, up to 1.8 lbs can be reduced from other structures in the vehicle (*i.e.*, a 180 percent factor). The report also discusses that a primary variable in the realized secondary weight reduction is whether or not the powertrain components can be included in the mass reduction effort, with the lower end estimates being applicable when powertrain elements are unavailable for mass reduction. However, another report by the Aluminum Association, which primarily focuses on the use of aluminum as an alternative material for steel, estimated a factor of 64 percent for secondary mass reduction even though some powertrain elements were considered in the analysis.[26] That report also notes that typical values for this factor vary from 50 to 100 percent. Although there is a wide variation in stated estimates, synergistic mass reductions do exist, and the effects result in tangible mass reductions. Mass reductions in a single vehicle component, for example a door side impact/intrusion system, may actually result in a significantly higher weight savings in the total vehicle, depending on how well the manufacturer integrates the modification into the overall vehicle design. Accordingly, care must be taken when reviewing reports on weight reduction methods and practices to ascertain if compounding effects have been considered or not.

Mass reduction is broadly applicable across all vehicle subsystems including the engine, exhaust system, transmission, chassis, suspension, brakes, body, closure panels, glazing, seats and other interior components, engine cooling systems and HVAC systems. It is estimated that up to 1.25 kilograms of secondary weight savings can be achieved for every kilogram of weight saved on a vehicle when all subsystems are redesigned to take into account the initial primary weight savings.[27,28]

Mass reduction can be accomplished by proven methods such as:

- Smart Design: Computer aided engineering (CAE) tools can be used to better optimize load paths within structures by reducing stresses and bending moments applied to structures. This allows better optimization of the sectional thicknesses of structural components to reduce mass while maintaining or improving the function of the component. Smart designs also integrate separate parts in a manner that reduces mass by

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[25] "Preliminary Vehicle Mass Estimation Using Empirical Subsystem Influence Coefficients," Malen, D.E., Reddy, K. Auto-Steel Partnership Report, May 2007, Docket EPA-HQ-OAR-2009-0472-0169. Accessed on the Internet on May 30, 2009 at: http://www.a-sp.org/database/custom/Mass%20Compounding%20-%20Final%20Report.pdf

[26] "Benefit Analysis: Use of Aluminum Structures in Conjunction with Alternative Powertrain Technologies in Automobiles," Bull, M. Chavali, R., Mascarin, A., Aluminum Association Research Report, May 2008, Docket EPA-HQ-OAR-2009-0472-0168. Accessed on the Internet on April 30, 2009 at: http://www.autoaluminum.org/downloads/IBIS-Powertrain-Study.pdf

[27] "Future Generation Passenger Compartment-Validation (ASP 241)" Villano, P.J., Shaw, J.R., Polewarczyk, J., Morgans, S., Carpenter, J.A., Yocum, A.D., in "Lightweighting Materials – FY 2008 Progress Report," U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Vehicle Technologies Program, May 2009, Docket EPA-HQ-OAR-2009-0472-0190.

[28] "Preliminary Vehicle Mass Estimation Using Empirical Subsystem Influence Coefficients," Malen, D.E., Reddy, K. Auto-Steel Partnership Report, May 2007, Docket EPA-HQ-OAR-2009-0472-0169. Accessed on the Internet on May 30, 2009 at: http://www.a-sp.org/database/custom/Mass%20Compounding%20-%20Final%20Report.pdf

combining functions or the reduced use of separate fasteners. In addition, some "body on frame" vehicles are redesigned with a lighter "unibody" construction.

- Material Substitution: Substitution of lower density and/or higher strength materials into a design in a manner that preserves or improves the function of the component. This includes substitution of high-strength steels, aluminum, magnesium or composite materials for components currently fabricated from mild steel.

- Reduced Powertrain Requirements: Reducing vehicle weight sufficiently allows for the use of a smaller, lighter and more efficient engine while maintaining or increasing performance. Approximately half of the reduction is due to these reduced powertrain output requirements from reduced engine power output and/or displacement, changes to transmission and final drive gear ratios. The subsequent reduced rotating mass (*e.g.*, transmission, driveshafts/halfshafts, wheels and tires) via weight and/or size reduction of components are made possible by reduced torque output requirements. Automotive companies have largely used weight savings in some vehicle subsystems to offset or mitigate weight gains in other subsystems from increased feature content (sound insulation, entertainment systems, improved climate control, panoramic roof, etc.).

- Lightweight designs have also been used to improve vehicle performance parameters by increased acceleration performance or superior vehicle handling and braking.

Many manufacturers have already announced final future products plans reducing the weight of a vehicle body through the use of high strength steel body-in-white, composite body panels, magnesium alloy front and rear energy absorbing structures reducing vehicle weight sufficiently to allow a smaller, lighter and more efficient engine. Nissan will be reducing average vehicle curb weight by 15% by 2015.[29] Ford has identified weight reductions of 250 to 750 lb per vehicle as part of its implementation of known technology within its sustainability strategy between 2011 and 2020[30] including the aluminum bodied 2015 F150 which may eventually share body panels with the heavy duty F250 version when it is redesigned. Mazda plans to reduce vehicle weight by 220 lbs per vehicle or more as models are redesigned.[31,32] Ducker International estimates that the average curb weight of light-duty vehicle fleet will decrease approximately 2.8% from 2009 to 2015 and approximately 6.5% from 2009 to 2020 via changes in automotive materials and increased change-over from previously used body-on-frame automobile and light-truck designs to newer unibody designs. While the opportunity for mass reductions available to the light-duty fleet may not in all cases be applied directly to the heavy-duty fleet due to the different designs for the expected duty cycles of a "work" vehicle, mass

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[29] "Lighten Up!," Brooke, L., Evans, H. Automotive Engineering International, Vol. 117, No. 3, March 2009.
[30] "2008/9 Blueprint for Sustainability," Ford Motor Company. Available at: http:// www.ford.com/go/sustainability (last accessed February 8, 2010).
[31] "Mazda to cut vehicle fuel consumption 30 percent by 2015," Mazda press release, June 23, 2009. Available at: http://www.mazda.com/publicity/release/2008/200806/080623.html (last accessed February 8, 2010).
[32] "Mazda: Don't believe hot air being emitted by hybrid hype," Greimel, H. Automotive News, March 30, 2009.

reductions are still available particularly to areas unrelated to the components necessary for the work vehicle aspects.

(ii) Low Rolling Resistance Tires

Tire rolling resistance is the frictional loss associated mainly with the energy dissipated in the deformation of the tires under load and thus influences fuel efficiency and CO_2 emissions. Other tire design characteristics (*e.g.*, materials, construction, and tread design) influence durability, traction (both wet and dry grip), vehicle handling, and ride comfort in addition to rolling resistance. A typical LRR tire's attributes would include: increased tire inflation pressure, material changes, and tire construction with less hysteresis, geometry changes (*e.g.*, reduced aspect ratios), and reduction in sidewall and tread deflection. These changes would generally be accompanied with additional changes to suspension tuning and/or suspension design.

(iii) Aerodynamic Drag Reduction

Many factors affect a vehicle's aerodynamic drag and the resulting power required to move it through the air. While these factors change with air density and the square and cube of vehicle speed, respectively, the overall drag effect is determined by the product of its frontal area and drag coefficient, Cd. Reductions in these quantities can therefore reduce fuel consumption and CO_2 emissions. Although frontal areas tend to be relatively similar within a vehicle class (mostly due to market-competitive size requirements), significant variations in drag coefficient can be observed. Significant changes to a vehicle's aerodynamic performance may need to be implemented during a redesign (*e.g.*, changes in vehicle shape). However, shorter-term aerodynamic reductions, with a somewhat lower effectiveness, may be achieved through the use of revised exterior components (typically at a model refresh in mid-cycle) and add-on devices that currently being applied. The latter list would include revised front and rear fascias, modified front air dams and rear valances, addition of rear deck lips and underbody panels, and lower aerodynamic drag exterior mirrors.

(6) What Are the Projected Technology Effectiveness Values and Costs~~?~~

The assessment of the technology effectiveness and costs was determined from a combination of sources. First an assessment was performed by SwRI under contract with the agencies to determine the effectiveness and costs on several technologies that were generally not considered in the Phase 1 GHG rule time frame. Some of the technologies were common with the light-duty assessment but the effectiveness and costs of individual technologies were appropriately adjusted to match the expected effectiveness and costs when implemented in a heavy-duty application. Finally, the agencies performed extensive outreach to suppliers of engine, transmission and vehicle technologies applicable to heavy-duty applications to get industry input on cost and effectiveness of potential GHG and fuel consumption reducing technologies.

To achieve the levels of the proposed standards for gasoline and diesel powered heavy-duty vehicles, a combination of the technologies previously discussed would be required respective to unique gasoline and diesel technologies and their challenges. Although some of the technologies may already be implemented in a portion of heavy-duty vehicles, none of the technologies discussed are considered ubiquitous in the heavy-duty fleet. Also, as would be expected, the available test data show that some vehicle models would not need the full complement of available technologies to achieve the proposed standards. Furthermore, many technologies can be further improved (e.g., aerodynamic improvements) from today's best levels, and so allow for compliance without needing to apply a technology that a manufacturer might deem less desirable.

Technology costs for HD pickups and vans are shown in Table VI-3~~Table VI-3.~~. These costs reflect direct and indirect costs to the vehicle manufacturer for the 2021 model year. See Chapter 2 of the Draft RIA for a more complete description of the basis of these costs.

Table VI-3 Technology Costs for HD Pickups & Vans Inclusive of Indirect Cost Markups for MY2021 (2012$)

Technology	~~Class 2b~~ Gasoline	~~Class 2b~~ Diesel	~~Class 3 Gasoline~~	~~Class 3 Diesel~~
Engine changes to accommodate low friction lubes	$6	$6	~~$6~~	~~$6~~
Engine friction reduction – level 1	$116			$116
Engine friction reduction – level 2	$254	$254	~~$254~~	~~$254~~
Dual cam phasing	$183	$183	~~$183~~	~~$183~~
Cylinder deactivation	$196	N/A	~~$196~~	~~N/A~~
Stoichiometric gasoline direct injection	$451	N/A	~~$451~~	~~N/A~~
Turbo improvements	N/A	$16	~~N/A~~	~~$16~~
Cooled EGR	$373	$373	~~$373~~	~~$373~~
Turbocharging & downsizing[a]	$671	N/A	~~$671~~	~~N/A~~
"Right-sized" diesel from larger diesel	N/A	$0	~~N/A~~	~~N/A~~
8s automatic transmission (increment to 6s automatic transmission)	$~~131~~457	$~~131~~457	~~$131~~	~~$131~~
Improved accessories – level 1	$82			$82
Improved accessories – level 2	$132	$132	~~$132~~	~~$132~~
Low rolling resistance tires – level ~~2~~1	$~~78~~10	$~~78~~10	~~$78~~	~~$78~~
Passive aerodynamic improvements (aero 1)	$51			$51
Passive plus Active aerodynamic improvements (aero2)	$230	$230	~~$230~~	~~$230~~
Electric (or electro/hydraulic) power steering	$151	$151	~~$151~~	~~$151~~
Mass reduction (10~~%)~~% on a 6500 lb vehicle)	$318	$318	~~$367~~	~~$367~~
Driveline friction reduction	$139	$139	~~$139~~	~~$139~~
~~Transmission management~~	~~$32~~	~~$32~~	~~$32~~	~~$32~~
Stop-start (no regenerative braking)	$539	$539	~~$539~~	~~$539~~
Mild HEV	$2730	$2730	~~$3150~~	~~$3150~~
Strong HEV	$~~3150~~6779	$~~3150~~6779	~~$3150~~	~~$3150~~

[a] Cost to downsize from a V8 OHC to a V6 OHC engine with twin turbos.

The CAFE model works by adding technologies in an incremental fashion to each particular vehicle in a manufacturer's fleet until that fleet complies with the imposed standards. It does this by following a predefined set of decision trees whereby the particular vehicle is placed on the appropriate decision tree and it follows the predefined progression of technology available on that tree. At each step along the tree, a decision is made regarding the cost of a given technology relative to what already exists on the vehicle along with the fuel consumption improvement it provides relative to the fuel consumption at the current location on the tree, prior to deciding whether to take that next step on the tree or remain in the current location. Because the model works in this way, the input files must be structured to provide costs and effectiveness values for each technology relative to whatever technologies have been added in earlier steps along the tree. Table VI-4~~Table VI-4~~ presents the cost and effectiveness values used in the CAFE model input files.

Table VI-4 CAFE Model Input Values for Cost & Effectiveness for Given Technologies[a]

	FC	Incremental Cost (2012$)[a,b]			
Technology	**Savings**	**2016**	**2021**	**2025**	**2030**
Improved Lubricants and Engine Friction Reduction	1.60%	24	24	24	23
Coupled Cam Phasing (SOHC)	3.82%	55	48	43	40
Dual Variable Valve Lift (SOHC)	2.47%	48	42	37	34
Cylinder Deactivation (SOHC)	3.70%	38	34	30	27
Intake Cam Phasing (DOHC)	0.00%	55	48	43	40
Dual Cam Phasing (DOHC)	3.82%	52	46	40	37
Dual Variable Valve Lift (DOHC)	2.47%	48	42	37	34
Cylinder Deactivation (DOHC)	3.70%	38	34	30	27
Stoichiometric Gasoline Direct Injection (OHC)	0.50%	79	71	61	57
Cylinder Deactivation (OHV)	3.90%	243	216	188	174
Variable Valve Actuation (OHV)	6.10%	61	54	47	44
Stoichiometric Gasoline Direct Injection (OHV)	0.50%	79	71	61	57
Engine Turbocharging and Downsizing					
Small Gasoline Engines	8.00%	573	518	441	412
Medium Gasoline Engines	8.00%	(35)	(12)	(62)	(47)
Large Gasoline Engines	8.00%	702	623	522	482
Cooled Exhaust Gas Recirculation	3.04%	428	382	332	308
Cylinder Deactivation on Turbo/downsized Eng.	1.70%	37	33	29	27
Lean-Burn Gasoline Direct Injection	4.30%	2,503	1,758	1,485	1,321
Improved Diesel Engine Turbocharging	2.51%	25	22	19	18
Engine Friction & Parasitic Reduction					
Small Diesel Engines	3.50%	301	269	253	216
Medium Diesel Engines	3.50%	386	345	325	277
Large Diesel Engines	3.50%	471	421	397	339
Downsizing of Diesel Engines (V6 to I-4)	11.10%	0	0	0	0
8-Speed Automatic Transmission[c]	5.00%	540	482	419	388
Electric Power Steering	1.00%	182	160	144	132

Improved Accessories (Level 1)	0.93%	105	93	83	77
Improved Accessories (Level 2)	0.93%	65	57	54	47
Stop-Start System	1.10%	871	612	517	460
Integrated Starter-Generator	3.20%	1,272	1,040	969	775
Strong Hybrid Electric Vehicle	17.20%	3,458	3,038	2,393	2,166
Mass Reduction (5%)	1.50%	0.32	0.28	0.24	0.22
Mass Reduction (additional 5%)	1.50%	0.98	0.87	0.75	0.68
Reduced Rolling Resistance Tires	1.10%	10	10	9	9
Low-Drag Brakes	0.40%	106	106	102	102
Driveline Friction Reduction	0.50%	173	153	137	126
Aerodynamic Improvements (10%)	0.70%	65	58	52	47
Aerodynamic Improvements (~~additional~~ add'l 10%)	0.70%	217	193	182	156

[a] Values for other model years available in CAFE model input files available at NHTSA web site.
[b] For mass reduction, cost reported on mass basis (per pound of curb weight reduction).
[c] 8 speed automatic transmission costs include costs for high efficiency gearbox~~,~~ and aggressive shift logic ~~and early torque converter lockup~~ whereas those costs were kept separate in prior analyses.

~~(7)~~ **Summary of ~~Alternative~~Alternatives Analysis**

~~(8)~~ (7)

The major outputs of the CAFE model analysis are summarized in Table VI-6~~Table VI-5~~ and Table VI-6~~Table VI-6~~ below for the flat and dynamic baselines, respectively. For a more detailed analysis of the alternatives, please refer to section D below as well as the draft RIA.

Table **VI**-5: Summary of HD Pickup and Van Alternatives' Analysis – Flat Baseline

Annual Standard Increase	2.0%/y	2.75%/y	3.5%/y	4.0%/y
Average Fuel Economy (miles per gallon)				
Required	19.04	19.81	20.57	21.14
Achieved	19.14	20.05	20.83	21.27
Average Fuel Consumption (gallons /100 mi.)				
Required	5.25	5.05	4.86	4.73
Achieved	5.22	4.99	4.80	4.70
Average Greenhouse Gas Emissions (g/mi)				
Required	495	476	458	446
Achieved	491	470	453	444
Technology Cost (vs. No-Action)				
Average ($)	578	1,015	1,655	2,080
Total ($m)	437	767	1,251	1,572

Commented [DOT4]: Values in this table to be updated by NHTSA.

Benefit-Cost Summary ($billion)				
Total Social Cost	2.2	3.8	6.2	8.5
Total Social Benefit	12.6	15.7	20.6	24.3
Net Social Benefit	10.4	11.9	14.4	15.8
Technology Penetration (%)				
VVT and/or VVL	46	46	46	46
Cylinder Deac.	29	21	21	21
Direct Injection	17	25	31	32
Turbocharging	55	63	63	63
8-Speed AT	67	90	96	97
EPS, Accessories	50	74	78	76
Stop-Start	0	0	3	14
Hybridization[a]	0	5	25	50
Aero. Improvements	23	62	78	75
Mass Reduction (vs. No-Action)				
CW (lb.)	239	211	325	313
CW (%)	3.7	3.2	5.0	4.8

[a] Includes mild hybrids (ISG) and strong HEVs.

Table VI-~~65~~66: Summary of HD Pickup and Van Alternatives' Analysis – Dynamic Baseline

Annual Standard Increase	2.0%/y	2.75%/y	3.5%/y	4.0%/y
Average Fuel Economy (miles per gallon)				
Required	19.04	19.81	20.57	21.14
Achieved	19.14	20.05	20.83	21.27
Average Fuel Consumption (gallons /100 mi.)				
Required	5.25	5.05	4.86	4.73
Achieved	5.22	4.99	4.80	4.70
Average Greenhouse Gas Emissions (g/mi)				
Required	495	476	458	446
Achieved	491	470	453	444
Technology Cost (vs. No-Action)				
Average ($)	578	1,015	1,655	2,080
Total ($m)	437	767	1,251	1,572
Benefit-Cost Summary ($billion)				
Total Social Cost	2.2	3.8	6.2	8.5
Total Social Benefit	12.6	15.7	20.6	24.3

Net Social Benefit	10.4	11.9	14.4	15.8
Technology Penetration (%)				
VVT and/or VVL	46	46	46	46
Cylinder Deac.	29	21	21	21
Direct Injection	17	25	31	32
Turbocharging	55	63	63	63
8-Speed AT	67	90	96	97
EPS, Accessories	50	74	78	76
Stop-Start	0	0	3	14
Hybridization[a]	0	5	25	50
Aero. Improvements	23	62	78	75
Mass Reduction (vs. No-Action)				
CW (lb.)	239	211	325	313
CW (%)	3.7	3.2	5.0	4.8

[a]~~Includes~~[a] Includes mild hybrids (ISG) and strong HEVs.

In general, the standards are expected to cause manufacturers to produce HD pickups and vans that are lighter, more aerodynamic, and more technologically complex across all the alternatives, while social benefits continue to increase across all alternatives. As shown, there is a major difference between the relatively small increases in required fuel economy and average incremental technology cost between the alternatives, suggesting that the challenge of improving fuel consumption and CO_2 emissions accelerates as stringency increases (i.e., that there may be a "knee" in the dependence of the challenge and on the stringency). Despite the fact that the required average fuel consumption level only changes by about ~~X~~2 to 3 percent between Alternative 4 and Alternative 5, average technology cost increases by more than ~~XX~~17 percent.

~~(9) Reasonableness of the Preferred Alternative and Feasibility of More Stringent Standardsof Alternatives 3 and 4 and~~ Consistency of the Proposed Standards with the Agencies' Respective ~~Statutory~~Legal Authorities

Based on the information currently before the agencies, we believe that Alternative 3 would be maximum feasible for this segment for the model years in question. Alternative 4 is also discussed in detail below because the agencies believe it is possible, depending on comments and additional information received during the comment period, that it could be within the agencies' discretion to determine that Alternative 4 could be maximum feasible in the final rule. The agencies seek comment to assist us in making that determination

The main difference between the feasibility of ~~More Stringent Standards~~

~~The preferred alternative (the proposed Alternative 3) is estimated to achieve 96% of the fuel economy level achieved in~~ and Alternative 4~~, at about 60 percent of~~ pertains to the average ~~vehicle cost, without~~underlying assumptions with respect to the ~~expected deployment of more advanced technology~~ adoption rates of different technologies over the period covered by the rule. ~~The preferred alternative (~~Alternative 3~~)~~ is estimated to achieve 96% of the fuel economy level achieved in Alternative 4, at about 60 percent of the average vehicle cost, without the expected deployment of more advanced technology. In particular, manufacturers are estimated to deploy strong hybrids in less than 5 percent of new vehicles (in MY2028) under Alternative 3, compared to more than 12 percent under Alternative 4. Less aggressive electrification technologies also appear on 15 percent of the new vehicles simulated to be produced in MY2028 under Alternative 4, but are entirely absent under Alternative 3. ~~To the extent that these more advanced technologies, like varying degrees of electrification, are of questionable utility to the vehicles in this sector, the agencies have chosen a preferred alternative in which their deployment is not expected to be necessary for manufacturers to achieve compliance with the proposed standards.~~

As part of the agencies' evaluations of the reasonableness and feasibility of the proposed standards, we also considered alternative standards that are summarized in Section X. Having determined that the proposed standards are feasible, we also considered whether the more alternative stringent standards might be more appropriate. In particular, we are giving special consideration to the standards that were analyzed as part of Alternative 4. ~~We note that both the proposed standards in Alternative 3 and the Alternative 4 standards rest on the same data with respect to technology effectiveness, technology cost, etc. Therefore, the different determinations regarding these two alternatives involve assessing and balancing a single set of facts differently.~~ We project the proposed standards to be achievable within known design cycles, and we believe these standards would allow different paths to compliance in addition to the one we outline and cost here. As discussed below and throughout this ~~proposal~~analysis, our proposal places a higher value on maintaining functionality and capability of vehicles designed for work (versus light-duty), and on the assurance of in use reliability and market acceptance of new technology, particularly in initial model years of the program, over considerations of cost effectiveness, rapid paybacks, and total net benefits. Nevertheless, it may be possible to have additional adoption rates of the technologies than we project so that further reductions could be available at reasonable cost and cost-effectiveness. ~~Based on what we know today, merely giving greater weight to total net benefits, and less to concerns of reliability and the market acceptance of new technology in initial model years could lead us to adopt standards more like those in Alternative 4.~~

~~Consistent with the Alternative 3 objectives and the Phase 1 approach,~~ The proposed standards are expected to cause manufacturers to aggressively implement technologies that are considered available in the time frame of this rule. Under this approach, manufacturers are expected to implement these technologies considered feasible and appropriate for HD pickups and vans at aggressive adoption rates on essentially all vehicles across this sector by 2025 model year. In the case of several of these technologies, they are expected to approach 100% adoption. This includes a combination of engine, transmission and vehicle technologies as described in this section across every vehicle.

Commented [DOT5]: References to 100% adoption should be accompanied by an explanation of how that is realistic (e.g. statistics on current adoption rates, additional detail on availability, etc). The table below is helpful in terms of adding granularity, but given that for many of the technologies, the assumptions are at 100% in either alternative, the text should elaborate on why this is realistic.

~~The proposed level of stringency also takes into consideration several challenges and risks that could be encountered in the heavy-duty pickup and van segment. For example, by choosing a preferred alternative in which the industry is expected to approach 100% penetration of all most technologies poses a high degree of risk to manufacturers in the event that a technology is not available to a manufacturer for any of a number of reasons. This could include issues with supply of certain technologies for this sector due to the lower volumes not attracting suppliers. This has been noted by vehicle manufacturers during the Phase 1 implementation with regard to introduction of lower rolling resistance tires for certain vehicles. Vehicle manufacturers are not in control of tire manufacturing and may be vulnerable to the market decisions of tire manufacturers~~.

There is also a high degree of sensitivity to the estimated effectiveness levels of individual technologies. At high penetration rates of all technologies on a vehicle, the result of a reduced effectiveness of even a single technology could be non-compliance with the standards. If the standards do not account for this uncertainty, there would be a real possibility that a manufacturer ~~could follow~~who followed the ~~models~~ exact technology path ~~and~~we project would not meet their target~~could be unable to meet the standard~~ because a technology behaved slightly differently in their application~~, they may not meet the standards if the standards do not account for this uncertainty.~~. The agencies have explored ~~this~~this uncertainty, among others, in the uncertainty analysis described in section D below.

As discussed above, the proposed standards in Alternative 3 and the Alternative 4 standards are based on the application of the ~~control~~ technologies described in this section. These technologies are projected to be available within the lead time provided, as discussed in Draft RIA Chapter 2.6. The proposed standards and Alternative 4 would require an aggressive implementation schedule of most of these technologies during the program phase-in. Heavy-duty pickups and vans would need to have a combination of many individual technologies to achieve the proposed standards. The proposed standards are projected to yield significant emission and fuel consumption reductions without requiring a large segment transition to strong hybrids, a technology that while successful in light-duty passenger cars, cross-over vehicles and SUVs, may impact vehicle work capabilities[33] and have questionable customer acceptance in a large portion of this segment dedicated to towing~~.~~[34]. ~~While more stringent levels are being considered across all the proposed heavy-duty sectors. However, based on current information, it appears that costs, benefits and technology acceptance would be best balanced with the proposed level of the standards. Our analysis shows that Alternative 4, on the other hand, would likely require that some manufacturers make significant use of mild and/or strong hybrids, which may not be acceptable in this market segment, especially for HD pickups.~~ The agencies' analysis estimates that Alternative 4 would potentially require the use of strong hybrids ~~in~~ in up

Commented [NCC6]: NCC flag

[33] Hybrid batteries, motors and electronics generally add weight to a vehicle and require more space which can result in conflicts with payload weight and volume objectives.
[34] Hybrid electric systems are not sized for situations when vehicles are required to do trailer towing where the combined weight of vehicle and trailer is 2 to 4 times that of the vehicle alone. During these conditions, the hybrid system will have ~~significantly~~ reduced effectiveness. Sizing the system for trailer towing is prohibitive with respect to hybrid component required sizes and the availability of locations to place larger components like batteries.

to 48%, depending on the mix of strong and mild hybrids, in 18%, and stop/start engine systems in 20% of gasoline pickups (the largest gasoline HD segment~~)~~.). ~~However~~ It is important to note that this analysis only shows one pathway to compliance, and the manufacturers may make other decisions, e.g., changing the mix of strong vs. mild hybrids, or applying electrification technologies to HD vans instead. The technology adoption rates projected for the proposed aAlternative 3al and Alternative 4 are shown in the ~~Table VI-6~~ below.

Commented [DOT7]: See comment in table below

Field Code Changed

Table VI-76 CAFE Model Technology Adoption Rates for Proposal and Alternative 4 on Gasoline Pickup Trucks

	Proposal (2.75% per year)		Alternative 4 (3.5% per year)	
Technology	*With strong hybrids*	*Without strong hybrids*	*With strong hybrids*	*Without strong hybrids*
Low friction lubricants	100%	100%	100%	100%
Engine friction reduction	100%	100%	100%	100%
Cylinder deactivation	56%	56%	56%	56%
Variable valve timing	56%	56%	56%	56%
Gasoline direct injection	0%	42%	0%	56%
8 speed transmission	86%	86%	100%	100%
Low rolling resistance tires	100%	100%	100%	100%
Aerodynamic drag reduction	86%	86%	100%	100%
Mass reduction and materials	86%	86%	100%	100%
Electric power steering	99%	99%	100%	100%
Improved accessories	85%	86%	86%	86%
Stop/start engine systems	0%	31%	20%	0%
Mild hybrid	0 - 56%[a]	56%	18 - 86%[a]	86%
Strong hybrid	Up to 23%	-	Up to 48%	-

[a] *depending on extent of strong hybrid adoption.*

Commented [DOT8]: Why is this an either/or? Couldn't there also be a scenario with some strong hybridization, with the mild hybridization falling somewhere between 0 and 56? This suggests possible overstatement of the expectation vis a vis strong hybrid. Same comment vis a vis the 48 in the column re: option 4.

In addition to the possibility of an increased level of hybridization, the agencies are also requesting comment on other possible outcomes associated with Alternative 4~~.~~; in particular, the possibility of certain van designs or other products being discontinued. Several manufacturers now offer or are moving to European style HD vans. Ford, for example, is discontinuing its E-series body on frame HD van and replacing it with the unibody Transit van for MY 2015. While other manufacturers have replaced their traditional style vans with new European style van designs, GM continues to offer the traditional ~~style van.~~ full frame style van with eight cylinder

Commented [JW9]: Is this CBI?

gasoline engines required for ~~significant~~higher towing capability. Typically, the European style vans are equipped with smaller engines offering better fuel consumption and lower CO_2 emissions but ~~often~~ with reduced towing capability~~.~~, similar to light-duty trucks. The agencies request comment on the potential for Alternative 4 in particular to ~~compel~~ incentivize GM to ~~replace~~discontinue its current traditional style van and replace it with ~~a~~an as yet to be designed European style van similar to its competitor's products. Such an outcome ~~c~~would limit consumer choice both on the style of van available in the marketplace and on the range of capabilities of the vehicles available. The agencies have not attempted to cost out this possible compliance path. The agencies request comments on the likelihood of this as a possible outcome of Alternative 4, and whether it would be appropriate. We are especially interested in comments on the potential impact on consumer choice and the costs associated with this type of wholesale vehicle model replacement.

In addition, another potential outcome of Alternative 4 would be that manufacturers could change the product utility. For example, ~~with~~although GM's traditional van discussed above, ~~which~~currently offers similar towing capacity as gasoline pick-ups, GM could choose to replace engines designed for those towing capacities with small gas or diesel engines. ~~While these smaller and lower fuel consuming engines (which consume less fuel) may be capable of performing some of the original capabilities, such as like payload capacities, they would may no longer have the towing capacity that some buyers require. The result may be that buyers could no longer purchase a gasoline van with significant towing capability and would instead purchase a gasoline pickup that meets their towing requirements.~~ The agencies request comment on the potential for Alternative 4 to lead to this type of compliance approach.

Commented [NCC_210]: This seems speculative. We are requesting comment on this issue, so manufacturers can tell us if they have these concerns.

The agencies also request comment on the possibility that Alternative 4 could lead to increased dieselization of the HD pickup and van fleet. Dieselization is not a technology path the agencies included in the analysis for the Phase 1 rule or the Phase 2 proposal but it is something the agencies could consider as a technology path under Alternative 4. As discussed earlier, diesel engines are fundamentally more efficient than gasoline engines~~,~~ providing the same power (even gasoline engines with the technologies discussed above~~.~~). Alternative 4 could result in manufacturers switching from gasoline engines to diesel engines in certain challenging segments. However, while technologically feasible, this pathway could cause a distortion in consumer choices and significantly increase the cost of those vehicles, particularly considering Alternative 4 ~~still~~ is projected to require penetration of some form of hybrid~~ization even on diesel powered vehicles. The combination of the added diesel cost and the added hybridization cost could be more than consumers would accept.~~ Also, if dieselization occurs by manufacturers equipping vehicles with larger diesel engines rather than "right-sized" engines, the towing capability of the vehicles could increase resulting in higher work factors for the vehicles, higher ~~standards~~targets, and reduced program benefits. The issue of surplus towing capability is also discussed above in VI.B. (1).

Commented [JW11]: We did not allow hybridization of diesels.

~~Table VI-6 DOT CAFE Model Technology Adoption Rates for Proposal and Alternative 4 on Gasoline Pickup Trucks~~

	~~Proposal (2.75% per year)~~		~~Alternative 4 (3.5% per year)~~	
~~Technology~~	~~*With strong hybrids*~~	~~*Without strong hybrids*~~	~~*With strong hybrids*~~	~~*Without strong hybrids*~~
~~Low friction lubricants~~	~~100%~~	~~100%~~	~~100%~~	~~100%~~
~~Engine friction reduction~~	~~100%~~	~~100%~~	~~100%~~	~~100%~~
~~Cylinder deactivation~~	~~56%~~	~~56%~~	~~56%~~	~~56%~~
~~Variable valve timing~~	~~56%~~	~~56%~~	~~56%~~	~~56%~~
~~Gasoline direct injection~~	~~0%~~	~~42%~~	~~0%~~	~~56%~~
~~8-speed transmission~~	~~86%~~	~~86%~~	~~100%~~	~~100%~~
~~Low rolling resistance tires~~	~~100%~~	~~100%~~	~~100%~~	~~100%~~
~~Aerodynamic drag reduction~~	~~86%~~	~~86%~~	~~100%~~	~~100%~~
~~Mass reduction and materials~~	~~86%~~	~~86%~~	~~100%~~	~~100%~~
~~Electric power steering~~	~~99%~~	~~99%~~	~~100%~~	~~100%~~
~~Improved accessories~~	~~85%~~	~~86%~~	~~86%~~	~~86%~~
~~Stop/start engine systems~~	~~0%~~	~~31%~~	~~20%~~	~~0%~~
~~Mild hybrid~~	~~0%~~	~~56%~~	~~18%~~	~~86%~~
~~Strong hybrid~~	~~23%~~	~~-~~	~~48%~~	~~-~~

The technologies associated with meeting the proposed standards are estimated to add costs to heavy-duty pickups and vans as shown in Table VI-8~~Table VI-8Table VI-7~~ and Table VI-9~~Table VI-9~~ for the flat baseline and dynamic baseline, respectively. These costs are relative to a vehicle meeting the MY2018 standard in each of the model years shown. Reductions associated with these costs and technologies are considerable, estimated at a 12 percent reduction of CO_2eq emissions from the MY 2018 baseline for gasoline and diesel engine equipped vehicles~~, estimated to result in reductions of XX MMT of CO_2eq emissions over the lifetimes of 2021 through 2025 MY vehicles~~.[35] The cost of controls ~~is~~would be fully recovered by the operator due to the associated fuel savings, with a payback period somewhere in the third year of ownership, as shown in Section IX.L of this preamble. Given the large emission reductions ~~based on use of feasible~~ we estimate would result from the technologies ~~which are~~we

[35] *See* Table VI-~~4~~5.

project to be feasible and available in the lead time provided, plus the lack of adverse impacts on vehicle safety or utility, EPA and NHTSA regard these proposed standards as appropriate and consistent with our respective statutory authorities under CAA Section 202 (a) and NHTSA's EISA authority under 49 U.S.C. 32902(k)(2). We also show the costs for the potential Alternative 4 standards in Table VI-10~~Table VI-10Table VI-8~~ and Table VI-11~~Table VI-11~~.

Table VI-8~~87~~ HD Pickups and Vans Incremental Technology Costs per Vehicle under the Proposed Standards – Flat Baseline (2012$)

	2021	2022	2023	2024	2025
HD Pickups & Vans	$~~599~~664	$~~592~~656	$~~875~~1,047	$~~908~~1,091	$~~933~~1,108

Table VI-9 HD Pickups and Vans Incremental Technology Costs per Vehicle under the Proposed Standards – Dynamic Baseline (2012$)

	2021	2022	2023	2024	2025
HD Pickups & Vans	$653	$644	$1,035	$1,080	$1,096

Table VI-10~~108~~ HD Pickups and Vans Incremental Technology Costs per Vehicle under the Potential Alternative 4 Standards – Flat Baseline (2012$)

	2021	2022	2023	2024	2025
HD Pickups & Vans	$~~736~~1,287	$~~726~~1,270	$1,~~226~~858	$1,~~299~~971	$1,~~306~~825

Table VI-11 HD Pickups and Vans Incremental Technology Costs per Vehicle under the Potential Alternative 4 Standards – Dynamic Baseline (2012$)

	2021	2022	2023	2024	2025
HD Pickups & Vans	$1,276	$1,258	$1,847	$1,960	$1,814

Commented [DOT12]: Can these tables be edited to also include payback period?

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D. Analysis of the Regulatory Alternatives for HD Pickups and Vans

Considering the establishment of potential HD pickup and van fuel consumption and GHG standards to follow those already in place through model year 2018, the agencies evaluated a range of potential regulatory alternatives. The agencies estimated the extent to which manufacturers might add fuel-saving and CO_2-avoiding technologies under each regulatory alternative, including the no-action alternative described in Section X. of this proposal. For HD pickups and vans both agencies analyzed two no-action alternatives, where one no-action alternative could be described as a "flat baseline" and the other as a "dynamic baseline". Please refer to Section X. of this proposal for a complete discussion of the assumptions that underlie these baselines. The agencies then estimated the extent to which additional technology that would be implemented to meet each regulatory alternative would incrementally (compared to the no-action alternative) impact costs to manufacturers and vehicle buyers, physical outcomes such as highway travel, fuel consumption, and greenhouse gas emissions, and economic benefits and costs to vehicle owners and society. The remainder of this section and portions of Sections VII through X present the regulatory alternatives the agencies have considered, summarize the agencies' analyses, and explain the agencies' selection of the HD pickup and van preferred alternative defined by today's proposed standards.

The agencies conducted coordinated and complementary analyses by employing both DOT's CAFE model and EPA's MOVES model and other analytical tools to project fuel consumption and GHG emissions impacts resulting from the proposed standards for HD pickups and vans, against both the flat and dynamic baselines. DOT's CAFE model was used to estimate fuel consumption and GHG emissions, including downstream vehicular emissions as well as emissions from upstream processes related to fuel production, distribution, and delivery. The CAFE model applies fuel properties (density and carbon content) to estimated fuel consumption in order to calculate vehicular CO_2 emissions, applies per-mile emission factors (in this analysis, from MOVES) to estimated VMT in order to calculate vehicular CH_4 and N_2O emissions (as well, as discussed below, of non-GHG pollutants), and applies per-gallon upstream emission factors (in this analysis, from GREET) in order to calculate upstream GHG (and non-GHG) emissions. EPA also ran its MOVES model for all HD categories, namely tractors and trailers, vocational vehicles and HD pickups and vans, to develop a consistent set of fuel consumption and CO_2 reductions for all HD categories. The MOVES runs followed largely the procedures described above, with some differences. MOVES used the same technology application rates and costs that are part of the inputs and outputs of the CAFE model to evaluate the proposed standards for HD pickup trucks and vans in terms of grams of CO_2 per mile or gallons of fuel per 100 miles.

While both agencies fully analyzed the regulatory alternatives against both baselines, NHTSA considered its primary analysis to be based on the dynamic baseline, where certain cost-effective technologies are assumed to be applied by manufacturers to improve fuel efficiency beyond the Phase 1 requirements in the absence of new Phase 2 standards. On the other hand, EPA considered both baselines and EPA's flat baseline analysis is presented in Sections VII through IX of this proposal as well as the draft Regulatory Impact Analysis accompanying this proposal. In Section X both EPA's flat and dynamic baseline analyses are presented for all of the regulatory alternatives. For the flat baseline certain cost effective technologies are assumed to be applied by manufacturers in the absence of new Phase 2 standards, but it is also assumed that manufacturers would not apply these technologies to improve HD pickup and van fuel efficiency beyond the Phase 1 standards. In other words, the flat baseline assumes that manufacturer innovation and optimization would be used for other purposes, such as to replace less cost-effective fuel efficiency technology or to improve other vehicle attributes such as torque or acceleration. For example, some HD pickup manufacturers have utilized technology that could have been optimized to improve fuel efficiency instead to improve HD pickup maximum torque ratings to improve towing capacity.

This section provides a discussion of the CAFE model, followed by the comprehensive results of the CAFE model against the dynamic baseline to show costs, benefits, and environmental impacts. This presentation of regulatory analysis is consistent with the agencies' presentation of similar analyses conducted in support of the agencies joint light-duty vehicle fuel economy and GHG regulations. The CAFE analysis against the flat baseline as well as EPA's complementary analysis of GHG impacts, non-GHG impacts, and economic and other impacts using MOVES is presented in Sections VII through IX of this proposal, as well as in the draft Regulatory Impact Analysis accompanying this proposal. These are presented side-by-side with the agencies' joint analyses of the other heavy-duty sectors (i.e., tractors, trailers, vocational vehicles). The presentation of the EPA analyses of HD pickups and vans in these sections is consistent with the agencies' presentation of similar analyses conducted as part of the agencies' joint HD Phase 1 regulations. The agencies' intention for presenting both of these complementary and coordinated analyses is to offer interested readers the opportunity to compare the regulatory alternatives considered for Phase 2 in both the context of our Phase 1 analytical approaches and our light-duty vehicle analytical approaches.

~~Considering the establishment of potential HD pickup and van fuel consumption and GHG standards to follow those already in place through model year 2018, the agencies evaluated a range of potential regulatory alternatives. The agencies estimated the extent to which manufacturers might add fuel-saving and CO_2-avoiding technologies under each regulatory alternative, including the no-action alternative defined by Phase 1 standards. The agencies then estimated the extent to which this additional technology would incrementally (compared to the no-action alternative) impact costs to manufacturers and vehicle buyers, physical outcomes such as highway travel, fuel consumption, and greenhouse gas emissions, and economic benefits and costs to vehicle owners and society. The remainder of this section presents the regulatory alternatives the agencies have considered, summarizes the agencies' analysis, and explains the agencies' selection of the preferred alternative defined by today's proposed standards.~~

(1) How Did the Agencies Evaluate the Regulatory Alternatives~~?~~

As discussed in section C above, the agencies used DOT's CAFE model to conduct an analysis of potential standards for HD pickups and vans. The basic operation of the CAFE model was described in section IV.C.2, so will not be repeated here. However, in this section we will provide additional detail on the model operation, inputs, assumptions, and ~~ouputs~~outputs.

DOT developed the CAFE model in 2002 to support the 2003 issuance of CAFE standards for MYs 2005-2007 light trucks. DOT has since significantly expanded and refined the model, and has applied the model to support every ensuing CAFE rulemaking

- 2006: MYs 2008-2011 light trucks
- 2008: MYs 2011-2015 passenger cars and light trucks (final rule prepared but withheld)
- 2009: MY 2011 passenger cars and light trucks
- 2010: MYs 2012-2016 passenger cars and light trucks (joint rulemaking with EPA)
- 2012: MYs 2017-2021 passenger cars and light trucks (joint rulemaking with EPA)

Past analyses conducted using the CAFE model have been subjected to extensive and detailed review and comment, much of which has informed the model's expansion and refinement. NHTSA's use of the model was considered and supported in *Center for Biological Diversity* v. *National Highway Traffic Safety Admin.*, 538 F.3d 1172, 1194 (9th Cir. 2008). For further discussion see 76 FR 57198~~2007 litigation (CBD v. NHTSA)~~, and the model has been subjected to formal peer review and review by the General Accounting Office (GAO) and National Research Council (NRC). NHTSA makes public the model, source code, and—except insofar as doing so would compromise confidential business information (CBI) manufacturers have provided to NHTSA—all model inputs and outputs underlying published rulemaking analyses.

This analysis reflects several changes made to the model since 2012, when NHTSA used the model to estimate the effects, costs, and benefits of final CAFE standards for light-duty vehicles produced during MYs 2017-2021, and augural standards for MYs 2022-2025. Some of these changes specifically enable analysis of potential fuel consumption standards (and, hence, related CO_2 emissions standards harmonized with fuel consumption standards) for heavy-duty pickups and vans; other changes implement more general improvements to the model. Key changes include the following:

- Expansion and restructuring of model inputs, compliance calculations, and reporting to accommodate standards for heavy-duty pickups and vans, including attribute-based standards involving targets that vary with "work factor".
- Explicit calculation of test weight, taking into account test weight "bins" and differences in the definition of test weight for light-duty vehicles (curb weight plus 300 pound) and heavy-duty pickups and vans (average of GVWR and curb weight).
- Procedures to estimate increases in payload when curb weight is reduced, increases in towing capacity if GVWR is reduced, and calculation procedures to correspondingly update calculated work factors.
- Expansion of model inputs, procedures, and outputs to accommodate technologies not included in prior analyses.
- Changes to the algorithm used to apply technologies, enabling more explicit accounting for shared vehicle platforms and adoption and "inheritance" of major engine changes.
- Expansion of the Monte Carlo simulation procedures used to perform probabilistic uncertainty analysis.

These changes are reflected in updated model documentation available at NHTSA's web site, the documentation also providing more information about the model's purpose, scope, structure, design, inputs, operation, and outputs. DOT invites comment on the updated model, and in particular, on the updated handling of shared vehicle platforms, engines, and transmissions, and on the new procedures to estimate changes to test weight, GVWR, and GCWR as vehicle curb weight is reduced.

(a) Product Cadence

Past comments on the CAFE model have stressed the importance of product cadence—i.e., the development and periodic redesign and freshening of vehicles—in terms of involving technical, financial, and other practical constraints on applying new technologies, and DOT has steadily made changes to the model with a view toward accounting for these considerations. For example, early versions of the model added explicit "carrying forward" of applied technologies between model years, subsequent versions applied assumptions that most technologies would be applied when vehicles are freshened or redesigned, and more recent versions applied assumptions that manufacturers would sometimes apply technology earlier than "necessary" in order to facilitate compliance with standards in ensuing model years. Thus, for example, if a manufacturer is expected to redesign many of its products in model years 2018 and 2023, and the standard's stringency increases significantly in model year 2021, the CAFE model will estimate the potential that the manufacturer will add more technology than necessary for compliance in MY 2018, in order to carry those product changes forward through the next redesign and contribute to compliance with the MY 2021 standard.

The model also accommodates estimates of overall limits (expressed as "phase-in caps" in model inputs) on the rates at which manufacturers' may practicably add technology to their respective fleets. So, for example, even if a manufacturer is expected to redesign half of its production in MY 2016, if the manufacturer is not already producing any strong hybrid electric vehicles (SHEVs), a phase-in cap can be specified in order to assume that manufacturer will stop applying SHEVs in MY 2016 once it has done so to at least 3% of its production in that model year.

After the light-duty rulemaking analysis accompanying the 2012 final rule regarding post-2016 CAFE standards and related GHG emissions standards, DOT staff began work on CAFE model changes expected to better reflect additional considerations involved with product planning and cadence. These changes, summarized below, interact with preexisting model characteristics discussed above.

(b) Platforms and Technology

The term "platform" is used loosely in industry, but generally refers to a common structure shared by a group of vehicle variants. The degree of commonality varies, with some platform variants exhibiting traditional "badge engineering" where two products are differentiated by little more than insignias, while other platforms be used to produce a broad suite of vehicles that bear little outer resemblance to one another.

Given the degree of commonality between variants of a single platform, manufacturers do not have complete freedom to apply technology to a vehicle: while some technologies (e.g. low rolling resistance tires) are very nearly "bolt-on" technologies, others involve substantial changes to the structure and design of the vehicle, and therefore necessarily are constant between vehicles that share a common platform. DOT staff has, therefore, modified the CAFE model such that all mass reduction and aero technologies are forced to be constant between variants of a platform. The agencies request comment on the suitability of this viewpoint, and which technologies can deviate from one platform variant to another.

Within the analysis fleet, each vehicle is associated with a specific platform. As the CAFE model applies technology, it first defines a platform "leader" as the vehicle variant of a platform with the highest technology utilization vehicle of mass reduction and aerodynamic technologies. As the vehicle applies technologies, it effectively harmonizes to the highest common denominator of the platform. If there is a tie, the CAFE model begins applying aerodynamic and mass reduction technology to the vehicle with the lowest average sales across all available model years. If there remains a tie, the model begins by choosing the vehicle with the highest average MSRP across all available model years. The model follows this formulation due to previous market trends suggesting that many technologies begin deployment at the high-end, low-volume end of the market as manufacturers build their confidence and capability in a technology, and later expand the technology across more mainstream product lines.

In the HD pickup and van market, there is a relatively small amount of diversity in platforms produced by manufacturers: typically 1-2 truck platforms and 1-2 van platforms. However, accounting for platforms will take on greater significance in future analyses involving the light-duty fleet, and the agency requests comments on the general use of platforms within CAFE rulemaking.

(c) Engine and Transmission Inheritance

In practice, manufacturers are limited in the number of engines and transmissions that they produce. Typically a manufacturer produces a number of engines—perhaps six or eight engines for a large manufacturer—and tunes them for slight variants in output for a variety of car and truck applications. Manufacturers limit complexity in their engine portfolio for much the same reason as they limit complexity in vehicle variants: they face engineering manpower limitations, and supplier, production and service costs that scale with the number of parts produced.

In previous usage of the CAFE model, engines and transmissions in individual models were allowed relative freedom in technology application, potentially leading to solutions that would, if followed, involve unaccounted-for costs associated with increased complexity in the product portfolio. The lack of a constraint in this area allowed the model to apply different levels of technology to the engine in each vehicle at the time of redesign or refresh, independent of what was done to other vehicles using a previously identical engine.

In the current version of the CAFE model, engines and transmissions that are shared between vehicles must apply the same levels of technology in all technologies dictated by engine or transmission inheritance. This forced adoption is referred to as "engine inheritance" in the model documentation.

As with platform-shared technologies, the model first chooses an "engine leader" among vehicles sharing the same engine. The leader is selected first by the vehicle with the lowest average sales across all available model years. If there is a tie, the vehicle with the highest average MSRP across model years is chosen. The model applies the same logic with respect to the application of transmission changes. As with platforms, this is driven by the concept that vehicle manufacturers typically deploy new technologies in small numbers prior to deploying widely across their product lines.

(d) Interactions between Regulatory Classes

Like earlier versions, the current CAFE model provides for integrated analysis spanning different regulatory classes, accounting both for standards that apply separately to different classes and for interactions between regulatory classes. Light vehicle CAFE standards are specified separately for passenger cars and light trucks. However, there is considerable sharing between these two regulatory classes. Some specific engines and transmissions are used in both passenger cars and light trucks, and some vehicle platforms span these regulatory classes. For example, some sport-utility vehicles are offered in 2WD versions classified as passenger cars and 4WD versions classified as light trucks. Integrated analysis of manufacturers' passenger car and light truck fleets provides the ability to account for such sharing and reduce the likelihood of finding solutions that could involve impractical levels of complexity in manufacturers' product lines. In addition, integrated analysis provides the ability to simulate the potential that manufactures could earn CAFE credits by overcomplying with one standard and use those credits toward compliance with the other standard (i.e., to simulate credit transfers between regulatory classes).

HD pickups and vans are regulated separately from light-duty vehicles. While manufacturers cannot transfer credits between light-duty and MDHD classes, there is some sharing of engineering and technology between light-duty vehicles and HD pickups and vans. For example, some passenger vans with GVWR over 8,500 pounds are classified as medium-duty passenger vehicles (MDPVs) and thus included in manufacturers' light-duty truck fleets, while cargo vans sharing the same nameplate are classified as HD vans.

While today's analysis examines the HD pickup and van fleet in isolation, as a basis for analysis supporting the planned final rule, the agencies intend to develop an overall analysis fleet spanning both the light-duty and HD pickup and van fleets. Doing so could show some technology "spilling over" to HD pickups and vans due, for example, to the application of technology in response to current light-duty standards. More generally, modeling the two fleets together should tend to more realistically limit the scope and complexity of estimated compliance pathways.

The agencies anticipate that the impact of modeling a combined fleet will primarily arise from engine-transmission inheritance. While platform sharing between the light-duty and MD pickup and van fleets is relatively small (MDPVs aside), there are a number of instances of engine and transmission sharing across the two fleets. When the fleets are modeled together, the agencies anticipate that engine inheritance will be implemented across the combined fleet, and therefore only one engine-transmission leader can be defined across the combined fleet. As with the fleets separately, all vehicles using a shared engine/transmission would automatically adopt technologies adopted by the engine-transmission leader.

The agencies request comment on plans to analyze the light-duty and MD pickup and van fleets jointly in support of planning for the final rule.

(e) Phase-In Caps

The CAFE model retains the ability to use phase-in caps (specified in model inputs) as proxies for a variety of practical restrictions on technology application. Unlike vehicle-specific restrictions related to redesign, refreshes or platforms/engines, phase-in caps constrain technology application at the vehicle manufacturer level. They are intended to reflect a manufacturer's overall resource capacity available for implementing new technologies (such as engineering and development personnel and financial resources), thereby ensuring that resource capacity is accounted for in the modeling process.

In previous CAFE rulemakings, redesign/refresh schedules and phase-in caps were the primary mechanisms to reflect an OEM's limited pool of available resources during the rulemaking time frame and the years leading up to the rulemaking time frame, especially in years where many models may be scheduled for refresh or redesign. The newly-introduced representation platform-, engine-, and transmission-related considerations discussed above augment the model's preexisting representation of redesign cycles and accommodation of phase-in caps. Considering these new constraints, inputs for today's analysis de-emphasize reliance on phase-in caps.

In this application of the CAFE model, phase-in caps are used only for the most advanced technologies included in the analysis, i.e., SHEVs and lean-burn GDI engines, considering that these technologies are most likely to involve implementation costs and risks not otherwise accounted for in corresponding input estimates of technology cost. For these two technologies, the agencies have applied caps that begin at 3% (i.e., 3% of the manufacturer's production) in MY 2017, increase at 3% annually during the ensuing nine years (reaching 30% in the MY 2026), and subsequently increasing at 5% annually for four years (reaching 50% in MY 2030). The agencies request comment on the appropriateness of these phase-in caps as proxies for constraints that, though not monetized by the agencies, nonetheless limit rates at which these two technologies can practicably be deployed, and on the appropriateness of setting inputs to stop applying phase-in caps to other technologies in this analysis. Comments on this issue should provide information supporting any alternative recommended inputs.

(f) Impact of Vehicle Technology Application Requirements

Compared to prior analyses of light-duty standards, these model changes, along with characteristics of the HD pickup and van fleet result in some changes in the broad characteristics of the model's application of technology to manufacturers' fleets. First, since the number of HD pickup and van platforms in a portfolio is typically small, compliance with standards may appear especially "lumpy" (compared to previous applications of the CAFE model to the more highly segmented light-duty fleet), with significant overcompliance when widespread redesigns precede stringency increases, and/or significant application of carried-forward (aka "banked") credits.

Second, since the use of phase-in caps has been de-emphasized and manufacturer technology deployment remains tied strongly to estimated product redesign and freshening schedules, technology penetration rates may jump more quickly as manufacturers apply technology to high-volume products in their portfolio.

By design, restrictions that enforce commonality of mass reduction and aerodynamic technologies on variants of a platform, and those that enforce engine inheritance, will result in fewer vehicle-technology combinations in a manufacturer's future modeled fleet. These restrictions are expected to more accurately capture the true costs associated with producing and maintaining a product portfolio.

(g) Accounting for Test Weight, Payload, and Towing Capacity

As mentioned above, NHTSA has also revised the CAFE model to explicitly account for the regulatory "binning" of test weights used to certify light-duty fuel economy and HD pickup and van fuel consumption for purposes of evaluating fleet-level compliance with fuel economy and fuel consumption standards. For HD pickups and vans, test weight (TW) is based on adjusted loaded vehicle weight (ALVW), which is defined as the average of gross vehicle weight rating (GVWR) and curb weight (CW). TW values are then rounded, resulting in TW "bins":

ALVW ≤ 4,000 lb.: TW rounded to nearest 125 lb.

4000 lb. < ALVW ≤ 5,500 lb.: TW rounded to nearest 250 lb.

ALVW > 5,500 lb.: TW rounded to nearest 500 lb.

This "binning" of TW is relevant to calculation of fuel consumption reductions accompanying mass reduction. Model inputs for mass reduction (as an applied technology) are expressed in terms of a percentage reduction of curb weight and an accompanying estimate of the percentage reduction in fuel consumption, setting aside rounding of test weight. Therefore, to account for rounding of test weight, NHTSA has modified these calculations as follows:

$$\Delta FC_{rounded\_TW} = \Delta TW \times \frac{\Delta FC_{unrounded\_TW}}{\Delta CW}$$

where:

ΔCW = % change in curb weight (from model input),

$\Delta FC_{unrounded\_TW}$ = % change in fuel consumption (from model input), without TW rounding,

ΔTW = % change in test weight (calculated), and

$\Delta FC_{rounded\_TW}$ = % change in fuel consumption (calculated), with TW rounding.

As a result, some applications of vehicle mass reduction will produce no compliance benefit at all, in cases where the changes in ALVW are too small to change test weight when rounding is taken into account. On the other hand, some other applications of vehicle mass reduction will produce significantly more compliance benefit than when rounding is not taken into account, in cases where even small changes in ALVW are sufficient to cause vehicles' test weights to increase by, e.g., 500 pounds when rounding is accounted for. Model outputs now include initial and final TW, GVWR, and GCWR (and, as before, CW) for each vehicle model in each model year, and the agencies invite comment on the extent to which these changes to account explicitly for changes in TW are likely to produce more realistic estimates of the compliance impacts of reductions in vehicle mass.

In addition, considering that the regulatory alternatives in the agencies' analysis all involve attribute-based standards in which underlying fuel consumption targets vary with "work factor" (defined by the agencies as the sum of three quarters of payload, one quarter of towing capacity, and 500 lb. for vehicles with 4WD), NHTSA has modified the CAFE model to apply inputs defining shares of curb weight reduction to be "returned" to payload and shares of GVWR reduction to be returned to towing capacity. The standards' dependence on work factor provides some incentive to increase payload and towing capacity, both of which are buyer-facing measures of vehicle utility. In the agencies' judgment, this provides reason to assume that if vehicle mass is reduced, manufacturers are likely to "return" some of the change to payload and/or towing capacity. For this analysis, the agencies have applied the following assumptions:

- GVWR will be reduced by half the amount by which curb weight is reduced. In other words, 50% of the curb weight reduction will be returned to payload.
- GCWR will not be reduced. In other words, 100% of any GVWR reduction will be returned to towing capacity.
- GVWR/CW and GCWR/GVWR will not increase beyond levels observed among the majority of similar vehicles (or, for outlier vehicles, initial values):

Table VI-129 Ratios for Modifying GVW and GCW as a Function of Mass Reduction

	Maximum Ratios Assumed Enabled by Mass Reduction	
Group	**GVWR/CW**	**GCWR/GVWR**
Unibody	1.75	1.50
Gasoline pickups > 13k GVWR	2.00	1.50
Other gasoline pickups	1.75	2.25
Diesel SRW pickups	1.75	2.50
All other	1.75	2.25

The first of two of these inputs are specified along with standards for each regulatory alternative, and the GVWR/CW and GCWR/GVWR "caps" are specified separately for each vehicle model in the analysis fleet.

In addition, DOT has changed the model to prevent HD pickup and van GVWR from falling below 8,500 pounds when mass reduction is applied (because doing so would cause vehicles to be reclassified as light-duty vehicles), and to treat any additional mass for hybrid electric vehicles as reducing payload by the same amount (e.g., if adding a strong HEV package to a vehicle involves a 350 pound penalty, GVWR is assumed to remain unchanged, such that payload is also reduced by 350 pounds).

The agencies invite comment on these methods for estimating how changes in vehicle mass may impact fuel consumption, GVWR, and GCWR, and on corresponding inputs to today's analysis.

(2) Development of the Analysis Fleet

As discussed above, the agencies used NHTSA's CAFE modeling system to estimate potential impacts under each regulatory alternative, including the no action alternative (which reflects continuation of previously-promulgated standards). Impacts under each of the "action" alternatives are calculated on an incremental basis relative to impacts under the no action alternative. The modeling system relies on many inputs, including an analysis fleet. In order to estimate the impacts of potential standards, it is necessary to estimate the composition of the future vehicle fleet. Doing so enables estimation of the extent to which each manufacturer may need to add technology in response to a given series of attribute-based standards, accounting for the mix and fuel consumption of vehicles in each manufacturer's regulated fleet. The agencies create an analysis fleet in order to track the volumes and types of fuel economy-improving and CO2-reducing technologies that are already present in the existing vehicle fleet. This aspect of the analysis fleet helps to keep the CAFE model from adding technologies to vehicles that already have these technologies, which would result in "double counting" of technologies' costs and benefits. An additional step involved projecting the fleet sales into MYs 2019-2030. This represents the fleet volumes that the agencies believe would exist in MYs 2019-2030. The following presents an overview of the information and methods applied to develop the analysis fleet, and some basic characteristics of that fleet.

The resultant analysis fleet is provided in detail at NHTSA's web site, along with all other inputs to and outputs from today's analysis. The agencies invite comment on this analysis fleet and, in particular, on any other information that should be reflected in an analysis fleet used to update the agencies' analysis for the final rule. Also, the agencies also invites comment on the potential expansion of this analysis fleet such that the impacts of new HD pickup and van standards can be estimated within the context of an integrated analysis of light-duty vehicles and HD pickups and vans, accounting for interactions between the fleets.

(a) Data sources

Most of the information about the vehicles that make up the 2014 analysis fleet was gathered from the 2014 Pre-Model Year Reports submitted to EPA by the manufacturers under Phase 1 of Fuel Efficiency and GHG Emission Program for Medium- and Heavy-Duty Trucks, MYs 2014-2018.

The major manufacturers of class 2b and class 3 trucks (Chrysler, Ford and GM) were asked to voluntarily submit updates to their Pre-Model Year Reports. Updated data were provided by Chrysler and GM. These updated data were used in constructing the analysis fleet for these manufacturers.

The agencies agreed to treat this information as Confidential Business Information (CBI) until the publication of the NPRM. This information can be made public at this time because by now all MY2014 vehicle models have been produced, which makes data about them essentially public information.

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These data (by individual vehicle configuration produced in MY2014) include: Projected Production Volume/MY2014 Sales, Drive Type, Axle Ratio, Work Factor, Curb Weight, Test Weight[36], GVWR, GCWR, Fuel Consumption (gal/100 mile), engine type (gasoline or diesel), engine displacement, transmission type and number of gears.

The column "Engine" of the Pre-Model Year report for each OEM was copied to the column "Engine Code" of the vehicle sheet of the CAFE model market data input file.[37] Values of "Engine" were changed to Engine Codes for use in the CAFE model. The codes indicated on the vehicle sheet map the detailed engine data on the engine sheet to the appropriate vehicle on the vehicle sheet of the CAFE model input file.

The column "Trans Class" of the Pre-Model Year report for each OEM was copied to the column "Transmission Code" of the vehicle sheet of the market data input file. Values of "Trans Class" were changed to Transmission Codes for use in the CAFE model. The codes indicated on the vehicle sheet map the detailed transmission data on the transmission sheet to the appropriate vehicle on the vehicle sheet of the CAFE model input file.

In addition to information about each vehicle, the agencies need additional information about the fuel economy-improving/CO_2-reducing technologies already on those vehicles in order to assess how much and which technologies to apply to determine a path toward future compliance. Thus, the agencies augmented this information with publicly-available data that includes more complete technology descriptions. Specific engines and transmissions associated with each manufacturer's trucks were identified using their respective internet sites. Detailed technical data on individual engines and transmissions indicated on the engine sheet and transmission sheet of the CAFE model input file were then obtained from manufacturer internet sites, spec sheets and product literature, Ward's Automotive Group and other commercial internet sites such as cars.com, edmunds.com, and motortrend.com.[38] Specific additional information included:

- "Fuel Economy on Secondary Fuel" was calculated as E85 = .74 gasoline fuel economy, or B20 = .98 diesel fuel economy. These values were duplicated in the columns "Fuel Economy (Ethanol-85)" and "Fuel Economy (Biodiesel-20)" of the CAFE market data input file.

- Values in the columns "Fuel Share (Gasoline)", "Fuel Share (Ethanol-85)", "Fuel Share (Diesel~~)",~~)," and "Fuel Share (Biodiesel-20)" are Volpe assumptions.

- The CAFE model also requires that values of Origin, Regulatory Class, Technology Class, Safety Class, and Seating (Max) be present in the file in order for the model to run. Placeholder values were added in these columns.

- In addition to the data taken from the OEM Pre Model Year submittals, NHTSA added additional data for use by the CAFE model. These included Platform, Refresh Years, Redesign Years, MSRP, Style, Structure and Fuel Capacity.[39]

- MSRP was obtained from web2carz.com and the OEM web sites.

- Fuel capacity was obtained from OEM spec sheets and product literature.

- The Structure values (Ladder, Unibody) used by the CAFE model were added. These were determined from OEM product literature and the automotive press. It should be noted that the new vans such as the Transit in fact utilize a ladder/unibody structure. Ford product literature uses the term "Uniladder" to describe the structure. Vans based on this structure are noted in the Vehicle Notes column of the NHTSA input file.

- Style values used by the CAFE model were also added: Chassis Cab, Cutaway, Pickup and Van.

(b) Vehicle Redesign Schedules and Platforms

Product cadence in the Class 2b and 3 pickup market has historically ranged from 7-9 years between major redesigns. However, due to increasing competitive pressures and consumer demands the agency anticipates that manufacturers will generally shift to shorter design cycles resembling those of the light duty market. Pickup truck manufacturers in the Class 2b and 3 segments are shown to adopt redesign cycles of six years, allowing two redesigns prior to the end of the regulatory period in 2025. The agencies request comment on the anticipated future use of redesign cycles in this product segment.

The Class 2b and 3 van market has changed markedly from five years ago. Ford, Nissan, Ram and Daimler have adopted vans of "Euro Van" appearance, and in many cases now use smaller turbocharged gasoline or diesel engines in the place of larger, naturally-aspirated V8s. The 2014 Model Year used in this analysis represents a period where most manufacturers, with the exception of General Motors, have recently introduced a completely redesigned product after many years. The van segment has historically been one of the slowest to be redesigned of any product segment, with some products going two decades or more between redesigns.

Due to new entrants in the field and increased competition, the agencies anticipate that most manufacturers will increase the pace of product redesigns in the van segment, but that they will continue to trail other segments. The cycle time used in this analysis is approximately ten years between major redesigns, allowing manufacturers only one major redesign during the regulatory period. The agencies request comment on this anticipated product design cycle.

Additional detail on product cadence assumptions for specific manufacturers is located in Chapter 2 of the draft RIA.

(c) Sales Volume Forecast

Since each manufacturer's required average fuel consumption and GHG levels are sales-weighted averages of the fuel economy/GHG targets across all model offerings, sales volumes play a critical role in estimating that burden. The CAFE model requires a forecast of sales volumes, at the vehicle model-variant level, in order to simulate the technology application necessary for a manufacturer to achieve compliance in each model year for which outcomes are simulated.

For today's analysis, the agencies relied on the MY 2014 pre-model-year compliance submissions from manufacturers to provide sales volumes at the model level based on the level of disaggregation in which the models appear in the compliance data. However, the agencies only use these reported volumes without adjustment for MY 2014. For all future model years, we combine the manufacturer submissions with sales projections from the 2014 Annual Energy Outlook Reference Case and IHS Automotive to determine model variant level sales volumes in future years.[40] The projected sales volumes by class that appear in the 2014 Annual Energy Outlook as a result of a collection of assumptions about economic conditions, demand for commercial miles traveled, and technology migration from light-duty pickup trucks in response to the concurrent light-duty CAFE/GHG standards. These are shown in Chapter 2 of the draft RIA.

For this analysis, the agencies have limited this analysis fleet to class 2b and 3 HD pickups and vans. However, especially considering interactions between the light-duty and HD pickup and van fleets (e.g., MDPVs being included in the light-duty fleet), the agencies are evaluating the potential to analyze the fleets in an integrated fashion for the final rule, and invite comment on the extent to which doing so could provide more realistic estimates of the incremental impacts of new standards applicable HD pickups and vans.

The projection of total sales volumes for the Class 2b and 3 market segment was based on the total volumes in the 2014 AEO Reference Case. For the purposes of this analysis, the AEO2014 calendar year volumes have been used to represent the corresponding model-year volumes. While AEO2014 provides enough resolution in its projections to separate the volumes for the Class 2b and 3 segments, the agencies deferred to the vehicle manufacturers and chose to rely on the relative shares present in the pre-model-year compliance data.

The relative sales share by vehicle type (van or pickup truck, in this case) was derived from a sales forecast that the agencies purchased from IHS Automotive, and applied to the total volumes in the AEO2014 projection. Table VI-13~~Table VI-10~~ shows the implied shares of the total new 2b/3 vehicle market broken down by manufacturer and vehicle type.

Table VI-13~~10~~ IHS Automotive Market Share Forecast for 2b/3 vehicles

		Model Year Market Share						
Manufacturer	**Style**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Daimler	Van	3%	3%	3%	3%	3%	3%	3%
Fiat	Van	2%	2%	2%	2%	2%	2%	3%
Ford	Van	16%	17%	17%	17%	18%	18%	18%
General Motors	Van	12%	12%	11%	12%	13%	13%	13%
Nissan	Van	2%	2%	2%	2%	2%	2%	2%
Daimler	Pickup	0%	0%	0%	0%	0%	0%	0%
Fiat	Pickup	14%	14%	14%	14%	11%	12%	12%
Ford	Pickup	28%	27%	30%	30%	30%	27%	26%
General Motors	Pickup	23%	23%	21%	21%	21%	22%	23%
Nissan	Pickup	0%	0%	0%	0%	0%	0%	0%

Within those broadly defined market shares, volumes at the manufacturer/model-variant level were constructed by applying the model-variant's share of manufacturer sales in the pre-model-year compliance data for the relevant vehicle style, and multiplied by the total volume estimated for that manufacturer and that style.

After building out a set of initial future sales volumes based on the sources described above, the agencies attempted to incorporate new information about changes in sales mix that would not be captured by either the existing sales forecasts or the simulated technology changes in vehicle platforms. In particular, Ford has announced intentions to phase out their existing Econoline vans, gradually shifting volumes to the new Transit platform for some model variants (notably chassis cabs and cutaways variants) and eliminating offerings outright for complete Econoline vans as early as model year 2015. In the case of complete Econoline vans, the volumes for those vehicles were allocated to MY2015 Transit vehicles based on assumptions about likely production splits for the powertrains of the new Transit platform. The volumes for complete Econoline vans were shifted at ratios of 50%, 35%, and 15% for 3.7 L, 3.5 L Eco-boost, and 3.2 L diesel, respectively. Within each powertrain, sales were allocated based on the percentage shares present in the pre-model-year compliance data. The chassis cab and cutaway variants of the Econoline were phased out linearly between MY2015 and MY2020, at which time the Econolines cease to exist in any form and all corresponding volume resides with the Transits.

(3) Additional Technology Cost and Effectiveness Inputs

In addition to the base technology cost and effectiveness inputs described in VI. ~~VI.C~~ of this preamble, the CAFE model has some additional cost and effectiveness inputs, described as follows.

The CAFE model accommodates inputs to adjust accumulated effectiveness under circumstances when combining multiple technologies could result in underestimation or overestimation of total incremental effectiveness relative to an "unevolved" baseline vehicle. These so-called synergy factors may be positive, where the combination of the technologies results in greater improvement than the additive improvement of each technology, or negative, where the combination of the technologies is lower than the additive improvement of each technology. The synergy factors used in this analysis are described in Table VI-14~~Table VI-11~~.

Table VI-14~~11~~ Technology Pair Effectiveness Synergy Factors for HD Pickups and Vans

Technology Pair	Adjustment	Technology Pair	Adjustment
8SPD/CCPS	-4.60%	IATC/CCPS	-1.30%
8SPD/DEACO	-4.60%	IATC/DEACO	-1.30%
8SPD/ICP	-4.60%	IATC/ICP	-1.30%
8SPD/TRBDS1	4.60%	IATC/TRBDS1	1.30%
AERO2/SHEV1	1.40%	MR1/CCPS	0.40%
CCPS/IACC1	-0.40%	MR1/DCP	0.40%
CCPS/IACC2	-0.60%	MR1/VVA	0.40%
DCP/IACC1	-0.40%	MR2/ROLL1	-0.10%
DCP/IACC2	-0.60%	MR2/SHEV1	-0.40%
DEACD/IATC	-0.10%	NAUTO/CCPS	-1.70%
DEACO/IACC2	-0.80%	NAUTO/DEACO	-1.70%
DEACO/MHEV	-0.70%	NAUTO/ICP	-1.70%

DEACS/IATC	-0.10%
DTURB/IATC	1.00%
DTURB/MHEV	-0.60%
DTURB/SHEV1	-1.00%
DVVLD/8SPD	-0.60%
DVVLD/IACC2	-0.80%
DVVLD/IATC	-0.60%
DVVLD/MHEV	-0.70%
DVVLS/8SPD	-0.60%
DVVLS/IACC2	-0.80%
DVVLS/IATC	-0.50%
DVVLS/MHEV	-0.70%
NAUTO/SAX	-0.40%
NAUTO/TRBDS1	1.70%
ROLL1/AERO1	0.10%
ROLL1/SHEV1	1.10%
ROLL2/AERO2	0.20%
SHFTOPT/MHEV	-0.30%
TRBDS1/MHEV	0.80%
TRBDS1/SHEV1	-3.30%
TRBDS1/VVA	-8.00%
TRBDS2/EPS	-0.30%
TRBDS2/IACC2	-0.30%
TRBDS2/NAUTO	-0.50%
VVA/IACC1	-0.40%
VVA/IACC2	-0.60%
VVA/IATC	-0.60%

The CAFE model also accommodates inputs to adjust accumulated incremental costs under circumstances when the application sequence could result in underestimation or overestimation of total incremental costs relative to an "unevolved" baseline vehicle. For today's analysis, the agencies have applied one such adjustment, increasing the cost of medium-sized gasoline engines by $513 in cases where turbocharging and engine downsizing is applied with variable valve actuation.

The agencies also applied cost inputs to address some costs encompassed neither by the agencies' estimates of the direct cost to apply these technologies, nor by the agencies' methods for "marking up" these costs to arrive at increases in the new vehicle purchase costs. To account for the additional costs that could be incurred if a technology is applied and then quickly replaced, the CAFE model accommodates inputs specifying a "stranded capital cost" specific to each technology. For today's analysis, the agencies applied inputs to apply about $78 of additional cost (per engine) if gasoline engine turbocharging and downsizing (separately for each "level" considered) is applied and then immediately replaced, declining steadily to zero by the tenth model year following initial application of the technology. The model also accommodates inputs specifying any additional changes owners might incur in maintenance and post-warranty repair costs. For today's analysis, the agencies applied inputs indicating that vehicles equipped with less rolling-resistant tires could incur additional tire replacement costs equivalent to $21-$23 (depending on model year) in additional costs to purchase the new vehicle. The agencies did not, however, include inputs specifying any potential changes repair costs that might accompany application of any of the above technologies. The agencies' sensitivity analysis, discussed below, includes a case in which repair costs are estimated using factors consistent with those underlying the indirect cost multipliers used to mark up direct costs for the agencies' central analysis.

The agencies invite comment on all efficacy and cost inputs involved in today's analysis and request that commenters provide any additional data or forward-looking estimates that could be used to support alternative inputs, including those related to costs beyond those reflected in the cost to purchase new vehicles.

(4) Other Analysis Inputs

In addition to the inputs summarized above, the agencies' analysis of potential standards for HD pickups and vans makes use of a range of other estimates and assumptions specified as inputs to the CAFE modeling system. Some significant inputs (e.g., estimates of future fuel prices) also applicable to other MDHD segments are discussed below in Section IX. Others more specific to the analysis of HD pickups and vans are as follows:

(a) Vehicle Survival and Mileage Accumulation:

Today's analysis estimates the travel, fuel consumption, and emissions over the useful lives of vehicles produced during model years 2014-2030. Doing so requires initial estimates of these vehicles' survival rates (i.e., shares expected to remain in service) and mileage accumulation rates (i.e., anticipated annual travel by vehicles remaining in service), both as a function of vehicle vintage (i.e., age). The agencies' estimates are based on an empirical analysis of changes in the fleet of registered vehicles over time, in the case of survival rates, and usage data collected as part of the last Vehicle In Use Survey (the 2002 VIUS), in the case of mileage accumulation.

(b) Rebound Effect

Expressed as an elasticity of mileage accumulation with respect to the fuel cost per mile of operation, the agencies have applied a rebound effect of 10% for today's analysis.

(c) On-Road "Gap"

The agencies have applied a 20% adjustment to reflect differences between on-road and laboratory performance.

(d) Fleet Population Profile

Though not reported here, cumulative fuel consumption and CO_2 emissions are presented in the accompanying draft EIS, and these calculations utilize estimates of the numbers of vehicles produced in each model year remaining in service in calendar year 2014. The initial age distribution of the registered vehicle population in 2014 is based on vehicle registration data acquired by NHTSA from R.L. Polk Company.

(e) Past Fuel Consumption Levels

Though not reported here, cumulative fuel consumption and CO_2 emissions are presented in the accompanying draft EIS, and these calculations require estimates of the performance of vehicles produced prior to model year 2014. Consistent with AEO 2014, the agencies have assumed that gasoline and diesel HD pickups and vans averaged 14.9 mpg and 18.6 mpg, respectively, with gasoline versions averaging about 48% of production.

(f) Long-Term Fuel Consumption Levels

Though not reported here, longer-term estimates of fuel consumption and emissions are presented in the accompanying draft EIS. These estimates include calculations involving vehicle produced after MY 2030 and, consistent with AEO 2014, the agencies have assumed that fuel consumption and CO_2 emission levels will continue to decline at 0.05% annually (compounded) after MY 2030.

(g) Payback Period

To estimate in what sequence and to what degree manufacturers might add fuel-saving technologies to their respective fleets, the CAFE model iteratively ranks remaining opportunities (i.e., applications of specific technologies to specific vehicles) in terms of effective cost, primary components of which are the technology cost and the avoided fuel outlays, attempting to minimize effective costs incurred.[41] Depending on inputs, the model also assumes manufacturers may improve fuel consumption beyond requirements insofar as doing so will involve applications of technology at negative effective cost—i.e., technology application for which buyers' up-front costs are quickly paid back through avoided fuel outlays. This calculation includes only fuel outlays occurring within a specified payback period. For today's analysis, the agencies have applied a payback period of 6 months. Thus, for example, a manufacturer already in compliance with standards will be projected to apply a fuel consumption improvement projected to cost $250 (i.e., as a cost that could be charged to the buyer at normal profit to the manufacturer) and reduce fuel costs by $500 in the first year of vehicle operation. The agencies have also conducted the same analysis applying a feedback of 0 months (i.e., assuming manufacturers would not be at all responsive to fuel prices). This method of estimating "voluntary" fuel consumption improvements is discussed further in Section IX, below.

(h) Civil Penalties

EPCA and EISA require that a manufacturer pay civil penalties if it does not have enough credits to cover a shortfall with one or both of the light-duty CAFE standards in a model year. While these provisions do not apply to HD pickups and vans, at this time, the CAFE model will show civil penalties owed in cases where available technologies and credits are estimated to be insufficient for a manufacturer to achieve compliance with a standard. We have excluded these model-reported estimates from today's analysis.

[41] Add reference to model documentation.

(i) Coefficients for Fatality Calculations

Today's analysis includes estimates of the extent to which HD pickups and vans produced during MYs 2014-2030 may be involved in fatal crashes, considering the mass, survival, and mileage accumulation of these vehicles, taking into account changes in mass and mileage accumulation under each regulatory alternative. These calculations make use of the same coefficients applied to light trucks by DOT in its 2012 rulemaking analysis supporting post-2017 CAFE standards.[42] Baseline rates of involvement in fatal crashes are 13.03 and 13.24 fatalities per billion miles for vehicles with initial curb weights above and below 4,594 pounds, respectively. Considering that the data underlying the corresponding statistical analysis included observations only through calendar year 2010, these rates are reduced by 9.6% to account for subsequent impacts of recent Federal Motor Vehicle Safety Standards (FMVSS) and anticipated behavioral changes (e.g., continued increases in seat belt use). For vehicles above 4,594 pounds—i.e., the majority of the HD pickup and van fleet—mass reduction is estimated to reduce the net incidence of highway fatalities by 0.34% per 100 pounds of removed curb weight, because in crashes involving multiple vehicles, fatalities among occupants of other vehicles will be reduced. For the few HD pickups and vans below 4,594 pounds, mass reduction is estimated to increase the net incidence of highway fatalities by 0.52% per 100 pounds. Consistent with new DOT guidance, the social cost of highway fatalities is estimated using a VSL (value of statistical life) of $9.36m in 2014, increasing thereafter at 1.18% annually.[43]

(j) Compliance Credit Provisions

Today's analysis accounts for the potential to ~~overcomply~~over comply with standards and thereby earn compliance credits, applying these credits to ensuing compliance requirements. In doing so, the agencies treat any unused carried-forward credits as expiring after five model years, consistent with current and proposed standards. For today's analysis, the agencies are not estimating the potential to "borrow"—i.e., to carry credits back to past mode years.

(k) Emission Factors

While CAFE model calculates vehicular CO_2 emissions directly on a per-gallon basis using fuel consumption and fuel properties (density and carbon content), the model calculates emissions of other pollutants (methane, nitrogen oxides, ozone precursors, carbon monoxide, sulfur dioxide, particulate matter, and air toxics) on a per-mile basis. In doing so, the agencies have applied corresponding emission factors estimated using EPA's MOVES model.[44] To estimate emissions (including CO_2) from upstream processes involved in producing, distributing,

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[42] NHTSA, "Corporate Average Fuel Economy for MY 2017-MY 2025 Passenger Cars and Light Trucks – Final Regulatory Analysis", pp. 1024-1025. Available at http://www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/FRIA_2017-2025.pdf.

[43] http://www.dot.gov/sites/dot.gov/files/docs/VSL_Guidance_2014.pdf.

[44] Add reference.

and delivering fuel, the agencies have applied emission factors—all specified on a gram per gallon basis—derived from Argonne National Laboratory's GREET model.[45]

(l) Refueling Time Benefits

To estimate the value of time savings associated with vehicle refueling, the agencies have applied estimates that an average refueling event involves refilling 60% of the tank's capacity over the course of 3.5 minutes, at an hourly cost of $27.22.

(m) External Costs of Travel

Changes in vehicle travel will entail economic externalities. To estimate these costs, the agencies have applied estimates that congestion-, accident-, and noise-related externalities will total 5.1 ¢/mi., 2.8 ¢/mi., and 0.1 ¢/mi., respectively.

(n) Ownership and Operating Costs

The agencies anticipate that the total cost of vehicle ownership and operation will change not just due to changes in vehicle price and fuel outlays, but also due to some other costs likely to vary with vehicle price. To estimate these costs, the agencies have applied factors of 5.5% (of price) for taxes and fees, 15.3% for financing, 19.2% for insurance, 1.9% for relative value loss. The agencies have also estimate that average vehicle resale value will increase by 25% of any increase in new vehicle price.

(5) Impacts of Regulatory Alternatives

(a) Industry Impacts

The agencies' analysis fleet provides a starting point for estimating the extent to which manufacturers might add fuel-saving (and, therefore, CO_2-avoiding) technologies under various regulatory alternatives, including the no-action alternative that defines a baseline relative to which to measure estimated impacts of new standards. The analysis fleet is a forward-looking projection of production of new HD pickups and vans, holding vehicle characteristics (e.g., technology content and fuel consumption levels) constant at model year 2014 levels, and adjusting production volumes based on recent DOE and commercially-available forecasts. This analysis fleet includes some significant changes relative to fleet information underlying analysis supporting the establishment of Phase 1 standards applicable starting in model year 2014; in particular, the analysis fleet includes some new HD vans (e.g., Ford's Transit and Fiat/Chrysler's Promaster) that are considerable more fuel-efficient than HD vans these manufacturers have previously produced for the U.S. market.

While the proposed standards are scheduled to begin in model year 2021, the requirements they define for model years 2021-2025 are likely to influence planning decisions

[45] Add reference.

made by manufacturers several years before they begin. This is true in light-duty planning, but accentuated by the comparatively long redesign cycles and small number of models offered for sale in the 2b/3 market segment. Additionally, manufacturers will respond to the cost and efficacy of available fuel consumption improvements, the price of fuel, and the requirements of the Phase 1 standards that specify maximum allowable average fuel consumption improvements and GHG levels for MY2014-MY2018 vehicles (the final standard for MY2018 is held constant for model years 2019 and 2020). The forward-looking nature of product plans that determine which vehicle models will be offered in the model years affected by the proposed standards lead to additional technology application to vehicles in the analysis fleet that occurs in the years prior to the start of the proposed standards. From the industry perspective, this means that manufacturers will incur costs to comply with the proposed standards in the baseline and that the total cost of the proposed regulations will include some costs that occur prior to their start, and represent incremental changes over a world in which manufacturers will have already modified their vehicle offerings compared to today.

Table VI-15~~12~~: MY2021 baseline costs for manufacturers in 2b/3 market segment

Manufacturer	Average Technology Cost	Total Cost Increase ($m)
Chrysler/Fiat	275	27
Daimler	18	0.4
General Motors	782	192
Ford	258	78
Nissan	282	3.3
Industry	442	300

As Table VI-15~~Table VI-12~~ shows, the industry as a whole is expected to add about $440 of new technology to each new vehicle model by 2021 under the no-action alternative defined by the Phase 1 standards. Reflecting differences in projected product offerings in the analysis fleet, some manufacturers (notably Daimler) are significantly less constrained by the Phase 1 standards than others and face lower cost increases as a result. General Motors (GM) shows the largest increase in average vehicle cost, but results for GM's closest competitors (Ford and Chrysler/Fiat) do not include the costs of their recent van redesigns, which are already present in the analysis fleet (discussed in greater detail below).

The above results reflect the assumption that manufacturers having achieved compliance with standards might act as if buyers are willing to pay for further fuel consumption improvements that "pay back" within 6 months. It is also possible, however unlikely, that manufacturers will not respond to buyers' demand for additional fuel economy as a result of increased fuel prices by any amount, and will choose not to migrate cost-effective technologies to the 2b/3 market segment from similar vehicles in the light-duty market. To examine this possibility, the agencies have also analyzed all regulatory alternatives using a 0-month payback period in lieu of the 6-month payback period discussed above. (The agencies' sensitivity analysis, discussed below, also explores longer payback periods, as well as the combined effect of payback period and fuel price.) Resultant technology costs in model year 2021 results for the no-action alternative, summarized in Table VI-16~~Table VI-13~~ below, are quite similar to those shown above for the 6-month payback period:

Field Code Changed

Table VI-16~~13~~: MY2021 baseline costs if manufacturers only respond to regulatory pressure

Manufacturer	Average Technology Cost ($)	Total Cost Increase ($m)
Chrysler/Fiat	268	27
Daimler	0	0
General Motors	767	188
Ford	248	75
Nissan	257	3
Industry	431	292

The results below represent the impacts of other regulatory alternatives, including those defined by the proposed standards, as incremental changes over the baseline, where the baseline is defined as the state of the world that is most likely to occur in the absence of the proposed regulatory action. Large-scale, macroeconomic conditions like fuel prices are constant across all alternatives, including the baseline, as are the fuel economy improvements under the no-action alternative defined by the Phase 1 MDHD rulemaking that covers model years 2014 – 2018 and is constant from model year 2018 through 2020. In the baseline scenario, the Phase 1 standards are assumed to remain in place and at 2018 levels throughout the analysis (i.e. MY 2030). The only difference between the definitions of the alternatives is the stringency of the proposed standards for MYs 2021 – 2025, and all of the differences in outcomes across alternatives are attributable to differences in the standards.

The standards vary in stringency across regulatory alternatives (1 – 5), but as discussed above, all of the standards are based on the curve developed in the Phase 1 standards that relate fuel economy and GHG emissions to a vehicle's work factor. The alternatives considered here represent different rates of annual increase in the curve defined for model year 2018, growing from a 0% annual increase (Alternative 1, the baseline or "no-action" alternative) up to a 4% annual increase (Alternative 5). Table VI-17~~Table VI-14~~ shows a summary[46] of outcomes by alternative incremental to the baseline (Alternative 1) for Model Year 2030[47], with the exception of technology penetration rates, which are absolute.

[46] The agencies generated hundreds of outputs related to economic and environmental impacts, each available technology, and the costs associated with the rule. A more comprehensive treatment of these outputs appears in Appendix [to the RIA] .

[47] The agencies have estimated that redesign schedules will "straddle" model year 2025, the latest year for which the agencies are proposing increases in the stringency of fuel consumption and GHG standards. Considering also that today's analysis estimates some earning and application of "carried forward" compliance credits, the agencies have extended today's analysis through model year 2030.

The technologies applied by the CAFE model have been grouped (in most cases) to give readers a general sense of which types of technology are applied more frequently than others, and are more likely to be offered in new class 2b/3 vehicles once manufacturers are fully compliant with the standards in the alternative. Model year 2030 was chosen to account for technology application that occurs once the standards have stabilized, but manufacturers are still redesigning products to achieve compliance – generating technology costs and benefits in those model years. The summaries of technology penetration are also intended to reflect the relationship between technology application and cost increases across the alternatives. The table rows present the degree to which specific technologies will be present in new class 2b and class 3 vehicles in 2030, and correspond to: Variable valve timing (VVT) and/or variable valve lift (VVL), cylinder deactivation, direct injection, engine turbocharging, 8-speed automatic transmissions, electric power-steering and accessory improvements, micro-hybridization (which reduces engine idle, but does not assist propulsion), full hybridization (integrated starter generator or strong hybrid that assists propulsion and recaptures braking energy), and aerodynamic improvements to the vehicle shape. In addition to the technologies in the following tables, there are some lower-complexity technologies that have high market penetration across all the alternatives and manufacturers; low rolling-resistance tires, low friction lubricants, and reduced engine friction, for example. (NOTE: THE SINGLE MODEL YEAR TABLES MAY BE CHANGED TO REFLECT VALUES FOR MY 2027, WHICH ARE NEARLY INDISTINGUISHABLE FROM WHAT APPEARS BELOW.)

Table VI-17~~14~~: Summary of 2b/3 Alternatives' impact on industry

Standard Increases	2.0%/y	2.75%/y	3.5%/y	4.0%/y
Average Fuel Economy (miles per gallon)				
Required	19.04	19.81	20.57	21.14
Achieved	19.14	20.05	20.83	21.27
Average Fuel Consumption (gallons /100 mi.)				
Required	5.25	5.05	4.86	4.73
Achieved	5.22	4.99	4.80	4.70
Average Greenhouse Gas Emissions (g/mi)				
Required	495	476	458	446
Achieved	491	470	453	444
Technology Penetration (%)				
VVT and/or VVL	46	46	46	46
Cylinder Deac.	29	21	21	21
Direct Injection	17	25	31	32
Turbocharging	55	63	63	63
8-Speed AT	67	90	96	97
EPS, Accessories	50	74	78	76
Stop Start	0	0	3	14
Hybridization[a]	0	5	25	50
Aero. Improvements	23	62	78	75

Mass Reduction (vs. No-Action)				
CW (lb.)	239	211	325	313
CW (%)	3.7	3.2	5.0	4.8
Technology Cost (vs. No-Action)				
Average ($)	578	1,015	1,655	2,080
Total ($m)	437	767	1,251	1,572
Payback period (m)[b]	25	27	34	38

~~[a]Includes~~[a] Includes mild hybrids (ISG) and strong HEVs.
[b] at a 3% discount rate.

In general, the standards cause manufacturers to produce HD pickups and vans that are lighter, more aerodynamic, and more technologically complex across all the alternatives. As Table VI-17~~Table VI-14~~ shows, there is a difference between the relatively small increases in required fuel economy and average incremental technology cost between the alternatives, suggesting that the challenge of improving fuel consumption and CO_2 emissions accelerates as stringency increases (i.e., that there may be a “knee” in the relationship between technology cost and reductions in fuel consumption/GHG emissions). Despite the fact that the required average fuel consumption level changes by about 3 percent between Alternative 4 and Alternative 5, average technology cost increases by more than 25 percent. The contrast between alternatives 3 and 4 is even more prominent, with a required fuel economy improvement of less than 4 percent leading to price increases greater than 60 percent. These differences help illustrate the clustered character of this market segment, where relatively small increases in fuel economy can lead to much larger cost increases if entire platforms must be changed in response to the standards. However, when considering payback period, the difference between Alternatives 3 and 4 is 7 months, while the difference between Alternatives 4 and 5 is only 4 months.

Manufacturers offer few models, typically only a pickup truck and/or a cargo van, and while there are a large number of variants of each model, the degree of component sharing across the variants can make diversified technology application either economically impractical or impossible. This forces manufacturers to apply some technologies more broadly in order to achieve compliance than they might do in other market segments (passenger cars, for example). This difference between broad and narrow application – where some technologies must be applied to entire platforms, while some can be applied to individual model variants – also explains why certain technology penetration rates decrease between alternatives of increasing stringency (aerodynamic improvements or mass reductions in , for example). For those cases, narrowly applying a more advanced (and costly) technology can be a more cost effective path to compliance and lead to reductions in the amount of lower-complexity technology that is applied.

One driver of the change in technology cost between Alternative 3 and Alternative 4 is the amount of hybridization resulting from the implementation of the standards. While only about 5 percent full hybridization (defined as either integrated starter-generator or strong hybrid) is expected to be required to comply with Alternative 3, the relatively small increase in stringency between Alternative 3 and Alternative 4 is enough to increase the percentage of the fleet adopting full hybridization by a factor of 5. To the extent that manufacturers are concerned about introducing hybrid vehicles in the 2b and 3 market, it is worth noting that Alternative 3 achieves about 96 percent of the fuel economy in Alternative 4, with almost no~~ne of the~~ hybridization required~~ to meet the more stringent alternative~~.

The alternatives also lead to important differences in outcomes at the manufacturer level, both from the industry average and from each other. General Motors, Ford, and Chrysler (Fiat), are expected to have approximately 95 percent of the 2b/3 new vehicle market during the years that the proposed standards are in effect. Due to their importance to this market and the similarities between their model offerings, these three manufacturers are discussed together and a summary of the way each is impacted by the standards appears below in Table VI-18~~Table VI-15~~, Table VI-19~~Table VI-16~~, and Table VI-20~~Table VI-17~~ for General Motors, Ford, and Chrysler/Fiat, respectively.

Table VI-18~~15~~: Summary of impacts on General Motors by 2030

Standard Increases	2.0%/y	2.75%/y	3.5%/y	4.0%/y
Average Fuel Consumption (gallons /100 mi.)				
Required	18.38	19.19	20	20.53
Achieved	18.43	19.18	20.24	20.51
Average Fuel Consumption (gallons /100 mi.)				
Required	5.44	5.21	5	4.87
Achieved	5.42	5.21	4.94	4.87
Average Greenhouse Gas Emissions (g/mi)				
Required	507	486	467	455
Achieved	505	486	461	455
Technology Penetration (%)				
VVT and/or VVL	64	64	64	64
Cylinder Deac.	47	47	47	47
Direct Injection	18	18	36	36
Turbocharging	53	53	53	53
8-Speed AT	36	100	100	100
EPS, Accessories	100	100	100	100
Stop Start	0	0	9	0
Hybridization	0	9	54	100
Aero. Improvements	64	100	100	100
Mass Reduction (vs. No-Action)				

CW (lb.)	325	198	158	164
CW (%)	5.3	3.2	2.6	2.7
Technology Cost (vs. No-Action)				
Average ($)	785	1,366	2,244	2,736
Total ($m)	214	372	611	746

Table VI-19~~16~~: Summary of impacts on Ford by 2030

Standard Increases	2.0%/y	2.75%/y	3.5%/y	4.0%/y
Average Fuel Consumption (gallons /100 mi.)				
Required	19.42	20.2	20.92	21.51
Achieved	19.5	20.72	21.28	21.8
Average Fuel Consumption (gallons /100 mi.)				
Required	5.15	4.95	4.78	4.65
Achieved	5.13	4.83	4.7	4.59
Average Greenhouse Gas Emissions (g/mi)				
Required	485	466	450	438
Achieved	482	454	443	433
Technology Penetration (%)				
VVT and/or VVL	34	34	34	34
Cylinder Deac.	18	0	0	0
Direct Injection	16	34	34	34
Turbocharging	51	69	69	69
8-Speed AT	100	100	100	100
EPS, Accessories	30	60	59	59
Stop Start	0	0	0	32
Hybridization	0	3	12	27
Aero. Improvements	0	60	60	60
Mass Reduction (vs. No-Action)				
CW (lb.)	210	199	379	356
CW (%)	3.2	3	5.7	5.3
Technology Cost (vs. No-Action)				
Average ($)	506	916	1,353	1,801
Total ($m)	170	307	454	604

Table VI-20~~17~~: Summary of impacts on Fiat/Chrysler by 2030

Standard Increases	2.0%/y	2.75%/y	3.5%/y	4.0%/y
Average Fuel Economy (miles per gallon)				
Required	18.73	19.38	20.12	20.70
Achieved	18.83	19.36	20.10	20.70
Average Fuel Consumption (gallons /100 mi.)				
Required	5.34	5.16	4.97	4.83
Achieved	5.31	5.16	4.97	4.83
Average Greenhouse Gas Emissions (g/mi)				
Required	515	497	479	466
Achieved	512	498	480	467
Technology Penetration (%)				
VVT and/or	40	40	40	40
Cylinder Deac.	23	23	23	23
Direct Injection	17	17	17	17
Turbocharging	74	74	74	74
8-Speed AT	65	65	88	88
EPS, Accessories	0	79	83	83
Stop-Start	0	0	0	0
Hybridization	0	0	2	12
Aero. Improvements	0	0	100	79
Mass Reduction (vs. No-Action)				
CW (lb.)	196	354	648	617
CW (%)	2.8	5	9.1	8.7
Technology Cost (vs. No-Action)				
Average ($)	434	703	1,486	1,700
Total ($m)	48	78	164	188

The fuel consumption and GHG standards require manufacturers to achieve an average level of compliance, represented by a sales-weighted average across the specific targets of all vehicles offered for sale in a given model year, such that each manufacturer will have a unique required consumption/emissions level determined by the composition of its fleet, as illustrated above. However, there are more interesting differences than the small differences in required fuel economy levels among manufacturers. In particular, the average incremental technology cost increases with the stringency of the alternative for each manufacturer, but the size of the cost increase from one alternative to the next varies among them, with General Motors and Fiat/Chrysler showing considerably larger increases in cost moving from Alternative 3 to Alternative 4, than from either Alternative 3 from Alternative 2 or Alternative 5 from Alternative

4. Ford is estimated to have more uniform cost increases from each alternative to the next, in increasing stringency.

The simulation results show all three manufacturers facing large cost increases when the stringency of the standards move from 2.75 percent to 3.5 percent per-year increases, but General Motors has the largest at 35 percent more than the industry average price increase for Alternative 4. GM also faces higher cost increases in Alternative 2, at least 50 percent more than either of its competitors. And for the most stringent alternative considered, the agencies estimate that General Motors would face average cost increases of more than $2,700, in addition to the more than $700 increase in the baseline – approaching nearly $3,500 per vehicle over today's prices.

Technology choices also differ by manufacturer, and some of those decisions are directly responsible for the largest cost discrepancies. For example, GM is estimated to engage in the least amount of mass reduction among the Big 3 after Phase 1, and much less than Chrysler/Fiat, but reduces average vehicle mass by over 300 pounds in the baseline – suggesting that some of GM's easiest Phase 1 compliance opportunities can be found in lightweighting technologies. Similarly, Chrysler/Fiat applies less hybridization than the others, and much less than General Motors, which is simulated to have full hybrids (either integrated starter generator or complete hybrid system) on all of its fleet by 2030, nearly 20 percent of which will be strong hybrids, in Alternative 4 and the strong hybrid share decreases to about 18 percent in Alternative 5, as some lower level technologies are applied more broadly. Because the agencies' analysis applies the same technology inputs and the same logic for selecting among available opportunities to apply technology, the unique situation of each manufacturer determined which technology path was the most cost-effective.

In order to understand the differences in incremental technology costs and fuel economy achievement across manufacturers in this market segment, it is important to understand the differences in their starting position relative to the proposed standards. One important factor, made more obvious in the following figures, is the difference between the fuel economy and performance of the recently redesigned vans offered by Fiat/Chrysler and Ford (the Promaster and Transit, respectively), and the more traditionally-styled vans that continue to be offered by General Motors (the Express/Savannah). In MY 2014, Ford began the phase-out of the Econoline van platform, moving those volumes to the Euro-style Transit vans (discussed in more detail in Section VI. ~~VI.)~~.D.2). The Transit platform represents a significant improvement over the existing Econoline platform from the perspective of fuel economy, and for the purpose of complying with the standards, the relationship between the Transit's work factor and fuel economy is a more favorable one than the Econoline vans it replaces. Since the redesign of van offerings from both Chrysler/Fiat and Ford occur in (or prior to) the 2014 model year, the costs, fuel consumption improvements, and reductions of vehicle mass associated with those redesigns are included in the analysis fleet, meaning they are not carried as part of the compliance modeling exercise. By contrast, General Motors is simulated to redesign their van offerings after 2014, such that there is a greater potential for these vehicles to incur additional costs attributable to new standards, unlike the costs associated with the recent redesigns of their competitors. The inclusion of these new Ford and Chrysler/Fiat products in the analysis fleet is the primary driver of the cost discrepancy between GM and its competitors in both the baseline and Alternative 2, when Ford and Chrysler/Fiat have to apply considerably less technology to achieve compliance.

The remaining 5 percent of the 2b/3 market is attributed to two manufacturers, Daimler and Nissan, which, unlike the other manufacturers in this market segment, only produce vans. The vans offered by both manufacturers currently utilize two engines and two transmissions, although both Nissan engines are gasoline engines and both Daimler engines are diesels. Despite the logical grouping, these two manufacturers are impacted much differently by the proposed standards. For the least stringent alternative considered, Daimler adds no technology and incurs no incremental cost in order to comply with the standards. At stringency increases greater than or equal to 3.5 percent per year, Daimler only really improves some of their transmissions and improves the electrical accessories of its Sprinter vans. By contrast, Nissan's starting position is much weaker and their compliance costs closer to the industry average in Table VI-17~~Table VI-14~~. This difference could increase if the analysis fleet supporting the final rule includes forthcoming Nissan HD pickups.

Table VI-21~~18~~: Summary of impacts on Daimler by 2030

Standard Increases	2.0%/y	2.75%/y	3.5%/y	4.0%/y
Average Fuel Economy (miles per gallon)				
Required	23.36	24.27	25.25	25.91
Achieved	25.23	25.23	25.79	26.53
Average Fuel Consumption (gallons /100 mi.)				
Required	4.28	4.12	3.96	3.86
Achieved	3.96	3.96	3.88	3.77
Average Greenhouse Gas Emissions (g/mi)				
Required	436	419	404	393
Achieved	404	404	395	384
Technology Penetration (%)				
VVT and/or VVL	0	0	0	0
Cylinder Deac.	0	0	0	0
Direct Injection	0	0	0	0
Turbocharging	44	44	44	44
8-Speed AT	0	0	44	100
EPS, Accessories	0	0	0	87
Stop-Start	0	0	0	0
Hybridization	0	0	0	0
Aero. Improvements	0	0	0	0
Mass Reduction (vs. No-Action)				
CW (lb.)	0	0	0	0
CW (%)	0	0	0	0

Technology Cost (vs. No-Action)				
Average ($)	0	0	165	374
Total ($m)	0	0	4	9

Table VI-22~~19~~: Summary of impacts on Nissan by 2030

Standard Increases	2.0%/y	2.75%/y	3.5%/y	4.0%/y
Average Fuel Economy (miles per gallon)				
Required	19.64	20.41	20.92	21.46
Achieved	19.84	20.7	21.19	21.51
Average Fuel Consumption (gallons /100 mi.)				
Required	5.09	4.9	4.78	4.66
Achieved	5.04	4.83	4.72	4.65
Average Greenhouse Gas Emissions (g/mi)				
Required	452	435	425	414
Achieved	448	430	419	413
Technology Penetration (%)				
VVT and/or VVL	100	100	100	100
Cylinder Deac.	49	49	49	49
Direct Injection	51	51	51	100
Turbocharging	51	51	51	50
8-Speed AT	0	0	51	51
EPS, Accessories	0	0	100	100
Stop-Start	0	0	0	0
Hybridization	0	0	0	28
Aero. Improvements	0	0	100	100
Mass Reduction (vs. No-Action)				
CW (lb.)	0	0	307	303
CW (%)	0	0	5	4.9
Technology Cost (vs. No-Action)				
Average ($)	378	736	1,347	1,935
Total ($m)	5	9.7	17.7	25.4

As Table VI-21~~Table VI-18~~ and Table VI-22~~Table VI-19~~ show, Nissan applies more technology than Daimler in the less stringent alternatives and significantly more technology with increasing stringency. The Euro-style Sprinter vans that comprise all of Daimler's model offerings in this segment put Daimler in a favorable position. However, those vans are already advanced – containing downsized diesel engines and advanced aerodynamic profiles. Much like the Ford Transit vans, the recent improvements to the Sprinter vans occurred outside the scope of the compliance modeling so the costs of the improvements are not captured in the analysis.

Although Daimler's required fuel economy level is much higher than Nissan's (in miles per gallon), Nissan starts from a much weaker position than Daimler and must incorporate additional engine, transmission, platform-level technologies (e.g. mass reduction and aerodynamic improvements) in order to achieve compliance. In fact, more than 25 percent of Nissan's van offerings become are projected to contain integrated starter generators by 2030 in Alternative 5.

While the agencies do not allow sales volumes for any manufacturer (or model) to vary across regulatory alternatives in the analysis, it is conceivable that under the most stringent alternatives individual manufacturers could lose market share to their competitors if the prices of their new vehicles rise more than the industry average without compensating fuel savings and/or changes to other features.

(b) Consumer Impacts

The consumer impacts of the rule are more straightforward. Table VI-23~~Table VI-20~~ shows the impact on the average consumer who buys a new class 2b or 3 vehicle in model year 2030. (NOTE: AS WITH THE OTHER TABLES ABOVE, THE MODEL YEAR IN THIS TABLE MAY BE CHANGED TO 2027, WHICH ONLY DIFFERS IN THE SECOND DECIMAL PLACE.) All dollar values are discounted at a rate of 7 percent per year from the time of purchase (except the average price increase, which occurs at the time of purchase).

Table VI-23~~20~~: Summary of individual consumer impacts in MY 2030

Standard	2.0%/y	2.75%/y	3.5%/y	4.0%/y
Value of Lifetime Fuel Savings (discounted 2012 dollars)				
Pretax	2,068	3,240	4,180	4,676
Tax	210	335	438	491
Total	2,278	3,575	4,618	5,168
Economic Benefits (discounted 2012 dollars)				
Mobility Benefit	244	368	472	525
Avoided Refueling Time	86	134	172	193
New Vehicle Purchase (vs. No-Action Alternative)				
Avg. Price Increase ($)	578	1,015	1,655	2,080
Avg. Payback (years)	2	2.3	2.8	3.2
Net Lifetime Consumer Benefits (discounted $)				

Total Net Benefits	2,030	3,062	3,607	3,806

As expected, a consumer's lifetime fuel savings increase monotonically across the alternatives. However, the roughly $600 increase in lifetime savings generated by moving from Alternative 4 to Alternative 5 is ~~considerably~~ smaller than the increase moving from Alternative ~~2~~ 3 to Alternative ~~3~~4, illustrating the diminishing returns to increasing fuel economy beyond some level. The mobility benefit in Table VI-23~~Table VI-20~~ refers to the value of additional miles that an individual consumer travels as a result of reduced per-mile travel costs. The additional miles result in additional fuel consumption and represent foregone fuel savings, but are valued by consumers at the cost of the additional fuel plus the consumer surplus (a measure of the increase in welfare that consumers achieve by having more mobility). The refueling benefit measures the value of time saved through reduced refueling events, the result of improved fuel economy and range in vehicles that have been modified in response to the standards.

There are some limitations to using payback period as a measure, as it accounts for fuel expenditures but not the cost of repairs or replacements, which may be more expensive with more advanced technology.

~~The payback period in Table VI-20 is naively defined as the number of years in which a driver accumulates enough savings in fuel expenditures to offset the price increase in the new vehicle purchase. A more realistic interpretation would include other factors that capture differences in purchase and ownership costs associated with additional technology that is applied to vehicles subject to the standards that would not have been present in the baseline (i.e. in the absence of the standards). The initial burden of purchase is impacted by the price of the vehicle, and includes obvious considerations like sales taxes, as well as less obvious cost increases like higher insurance costs or registration fees. The total cost of ownership, while dominated by fuel expenditures (particularly in the early years), more realistically includes the differential cost in replacing more advanced tires or lower friction lubricants during oil changes, battery replacement costs for hybrid vehicles, or plausibly more expensive or frequent repairs of advanced engines. These missing components are likely to be considerably smaller in magnitude than the changes in fuel expenditures, but have the potential to lengthen payback periods by some amount. For commercial operators, the time that a vehicle spends out of service can also have detrimental effects on the business's ability to function. The economic cost of that downtime would represent another consideration in the total cost of ownership. Table VI-20 shows payback periods smaller than 3.5 years for all the alternatives considered. The cost increase incurred when moving from Alternative 3 to Alternative 4 is not sufficiently offset by the value of the fuel savings in the early years, leading to an increase in the length of the payback period by about 6 months.~~

Overall, the average consumer is likely to see discounted lifetime benefits that are multiples of the price increases faced when purchasing the new vehicle in MY 2030 (or the few model years preceding 2030). In particular, the net present value of future benefits at the time of purchase are estimated to be 3.5, 3.0, 2.2, and 1.8 times the price increase of the average new MY2030 vehicle for Alternatives 2 – 5, respectively.

(c) Social and Environmental Impacts

~~As one should expect, the s~~Social benefits increase ~~monotonically~~ with the increasing stringency of the alternatives ~~– more fuel saved equates to larger benefits for increasingly stringent alternatives~~. ~~However, A~~As in the consumer analysis, the net benefits continue to increase with increasing stringency – suggesting that benefits are still increasing faster than costs for even the most stringent alternative.

Table VI-24~~21~~: Summary of total social costs and benefits through MY2027

Standard Increase	2.00%	2.75%	3.50%	4.00%
Fuel Purchases ($billion)				
Pretax Savings	7	10.6	14	16.5
Fuel Externalities ($billion)				
Energy Security	0.2	0.4	0.5	0.6
CO2 emissions	1.4	2.2	2.9	3.4
VMT-Related Externalities ($billion)				
Driving Surplus	0.8	1.2	1.5	1.8
Refueling Surplus	0.3	0.4	0.6	0.7
Congestion	-0.2	-0.2	-0.3	-0.4
Accidents	-0.1	-0.1	-0.2	-0.2
Noise	0	0	0	0
Fatalities	0.1	-0.2	-0.2	-0.3
Criteria Emissions	0.6	0.9	1.1	1.3
Technology Costs vs. No-Action ($billion)				
Incremental Cost	1.9	3.3	5.5	7.6
Benefit Cost Summary ($billion)				
Total Social Cost	2.2	3.8	6.2	8.5
Total Social Benefit	12.6	15.7	20.6	24.3
Net Social Benefit	10.4	11.9	14.4	15.8

Table VI-24~~Table VI-21~~ provides a summary of benefits and costs, cumulative from MY2015 – MY2027 (although the early years of the series typically have no incremental costs and benefits over the baseline), for each alternative. In the social perspective, fuel savings are considered net of fuel taxes, which are a transfer from purchasers of fuel to society at large. The energy security component represents the risk premium associated with exposure to oil price spikes and the economic consequences of adapting to them. This externality is monetized on a per-gallon basis, just as the social cost of carbon is used in this analysis. Just as the previous two externalities are caused by fuel consumption, others are caused by travel itself. The additional VMT resulting from the increase in travel demand that occurs when the price of driving decreases (i.e. the rebound effect), not only leads to increased mobility (which is a benefit to drivers), but also to increases in congestion, noise, accidents, and per-mile emissions of criteria pollutants like carbon monoxide and diesel particulates. Although increases in VMT lead to increases in tailpipe emissions of criteria pollutants, the proposed regulations decrease overall consumption enough that the emissions reductions associated with the remainder of the fuel cycle (extraction, refining, transportation and distribution) are large enough to create a net reduction in the emissions of criteria pollutants (shown below in Table VI-25~~Table VI-22~~ and Table VI-26~~Table VI-23~~).[48]

Another side effect of increased VMT is the likely increase in traffic fatalities, which is a function of the total vehicle travel in each year. As Table VI-24~~Table VI-21~~ illustrates, the positive social cost associated with traffic fatalities is the result of an additional -9 (implying that Alternative 2 actually leads to a reduction in fatalities over the baseline, due to the application of mass reduction technologies), 24, 24, and 47 fatalities for Alternatives 2-5, respectively. To put those numbers in context, the baseline contains over 21,000 fatalities attributable to 2b/3 vehicles over the same period. The incremental fatalities associated with the alternatives translate to less than -0.4, 0.1, 0.1, and 0.2 percent increases over the MY2015-2027 baseline, respectively.

One notable facet of Table VI-24~~Table VI-21~~ is the categorization of benefits; while consumer benefits are also social benefits, the external portions of the net benefits to society (composed of reductions in CO2 emissions, improved energy security, congestion, accidents, noise, and criteria pollutant emissions) are smaller than the total technology cost in each alternative. In the case of the more stringent alternatives, they sum to only about half the technology cost, whereas pretax fuel savings, alone, are considerably greater than technology costs for each regulatory alternative. Therefore, while any of the regulatory alternatives considered today would be cost-beneficial considering only buyer's avoided pretax fuel outlays, none would be cost-beneficial considering only economic externalities.

The agencies have used the CAFE model to estimate the emissions impacts of the various alternatives that are the result of lower fuel consumption, but increased vehicle miles traveled for vehicle produced in model years subject to the standards in the alternatives. Criteria pollutants are largely the result of vehicle use, and accrue on a per-mile-of-travel basis, but the alternatives still generally lead to emissions reductions. Although vehicle use increases under each of the alternatives, upstream emissions associated with fuel refining, transportation and distribution are reduced for each gallon of fuel saved and that savings is larger than the incremental increase in emissions associated with increased travel. The net of the two factors is a savings of criteria (and other) pollutant emissions.

Table VI-25~~22~~: Summary of environmental impacts through MY2027, dynamic baseline

Annual Std. Increase	2.0%	2.75%	3.5%	4.0%
Greenhouse Gas Emissions vs. No-Action Alternative				
CO2 (MMT)	40	60	79	92

[48] For a more detailed discussion of the results from the CAFE Model on the proposed heavy duty pickups and vans regulation's impact on emissions of CO2 and criteria pollutants, see NHTSA's accompanying Environmental Impact Statement~~, XX.~~.

CH4 and N2O (tons)	47,100	72,200	95,700	112,700
Other Emissions vs. No-Action Alternative (tons)				
CO	6,970	12,920	18,210	21,860
VOC and NOx	19,440	30,460	40,780	47,990
PM	1,130	1,670	2,190	2,570
SO2	9,140	13,600	17,870	21,030
Air Toxics	32	34	38	44
Diesel PM10	1,800	2,710	3,590	4,230
Other Emissions vs. No-Action Alternative (% reduction)				
CO	0.1	0.2	0.3	0.3
VOC and NOx	1.0	1.6	2.1	2.5
PM	1.5	2.2	2.9	3.4
SO2	2.5	3.7	4.8	5.7
Air Toxics	0.1	0.1	0.1	0.1
Diesel PM10	2.3	3.5	4.6	5.4

In addition to comparing environmental impacts of the alternatives against a dynamic baseline that shows some improvement over time, compared to today's fleet, even in the absence of the alternatives, the agencies compared environmental impacts against a flat baseline that assumes no technological change in new class 2b/3 vehicles over the next two decades. This other comparison is summarized below, but both comparisons are discussed in greater detail in the EIS.

Table VI-26~~23~~: Summary of environmental impacts through MY2027, flat baseline

Annual Std. Increase	2.0%	2.75%	3.5%	4.0%
Greenhouse Gas Emissions vs. No-Action Alternative				
CO2 (MMT)	47	68	92	103
CH4 and N2O (tons)	57,300	82,400	112,600	125,100
Other Emissions vs. No-Action Alternative (tons)				
CO	7,680	13,540	19,950	23,050
VOC and NOx	23,570	34,570	47,610	53,070
PM	1,400	1,940	2,620	2,890
SO2	11,270	15,790	21,340	23,580
Air Toxics	42	46	54	56
Diesel PM10	2,210	3,140	4,260	4,720
Other Emissions vs. No-Action Alternative (% reduction)				
CO	0.1	0.2	0.3	0.4
VOC and NOx	1.2	1.8	2.5	2.7
PM	1.8	2.6	3.4	3.8
SO2	3.0	4.2	5.7	6.3
Air Toxics	0.1	0.1	0.2	0.2
Diesel PM10	2.8	4.0	5.4	6.0

(6) Sensitivity Analysis to Different Inputs

[NOTE: This section to be updated. Not all cases listed below have been evaluated yet.]

OMB Circular A-4 indicates that "it is usually necessary to provide a sensitivity analysis to reveal whether, and to what extent, the results of the analysis are sensitive to plausible changes in the main assumptions and numeric inputs."[49] Considering this guidance, NHTSA performed a number of sensitivity analyses to examine important assumptions and inputs, including the following, all of which are discussed in greater detail in the accompanying RIA:

1. Payback Period: In addition to the 0 and 6 month payback periods discussed above, NHTSA also evaluated cases involving payback periods of 12, 18, and 24 months.
2. Fuel Prices: NHTSA evaluated cases involving fuel prices from the AEO 2014 low and high oil price scenarios.
3. Fuel Prices and Payback Period: NHTSA evaluated one side case involving a 0 month payback period combined with fuel prices from the AEO 2014 low oil price scenario, and one side case with a 24 month payback period combined with fuel prices from the AEO 2014 high oil price scenario.
4. Benefits to Vehicle Buyers: The main analysis assumes there is no loss in value to consumers resulting from vehicles that have an increase in price and higher fuel economy. This sensitivity analysis assumes that there is a 25, or 50 percent loss in value to consumers – equivalent to the assumption that consumers will only value the calculated benefits they will achieve at 75, or 50 percent, respectively, of the main analysis estimates.
5. Value of Avoided GHG Emissions: NHTSA evaluated side cases involving lower and higher valuation of avoided CO_2 emissions, expressed as the social cost of carbon (SCC). The agencies also evaluated a side case involving valuation of methane (CH_4) and nitrous oxide (N_2O) emissions.
6. Rebound Effect: NHTSA evaluated side cases involving rebound effect values of 5%, 15%, and 20%.
7. Markup of Direct Costs: NHTSA evaluated a side case where a factor of 1.5 was used
8. RPE-based Markup: NHTSA evaluated a side case using a retail price equivalent (RPE) markup factor of 1.5 for non-electrification technologies, which is consistent with the NAS estimation for technologies manufactured by suppliers, and a RPE markup factor of 1.33 for electrification technologies (HEV, PHEV and EV).
9. ICM-based Post-Warranty Repair Costs: NHTSA evaluated a side case that scaled the frequency of repair by vehicle survival rates, assumes that per-vehicle repair costs during the post-warranty period are the same as in the in-warranty period, and that repair costs

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[49] Available at http://www.whitehouse.gov/omb/circulars_a004_a-4/.

are proportional to incremental direct costs (therefore vehicles with additional components will have increased repair costs).

10. Mass-Safety Effect: NHTSA evaluated side cases with the mass-safety impact coefficient at the values defining the 5th and 95th percent points of the confidence interval estimated in the underlying statistical analysis.
11. Strong HEVs: NHTSA evaluated a side case in which strong HEVs were excluded from the set of technology estimated to be available for HD pickups and vans through model year 2030.
12. Diesel Downsizing: NHTSA evaluated a side case in which downsizing of diesel engines was estimated to be more widely available to HD pickups and vans.
13. Technology Effectiveness: NHTSA evaluated side cases involving inputs reflecting lower and higher impacts of technologies on fuel consumption.
14. Technology Direct Costs: NHTSA evaluated side cases involving inputs reflecting lower and higher direct incremental costs for fuel-saving technologies.
15. Fleet Mix: NHTSA evaluated a side case in which the shares of individual vehicle models and configurations were kept constant at estimated current levels.

Table VI-27~~Table VI-24~~ below, summarizes key results for each of the cases included in NHTSA's sensitivity analysis. More detailed results are available in the accompanying RIA.

Table VI-~~24~~27 Sensitivity Analysis Results from CAFE Model

[Note: Table columns show some likely metrics. Will be refined and updated.]

Case	VMT	Fuel	Per-Vehicle Costs	Buyers' Benefits	Social Benefits	Social Costs	Social Net Benefits
Reference (6-mo. payback)							
0-mo. payback							
12-mo. payback							
18-mo. payback							
24-mo. payback							
Low fuel prices							
High fuel prices							
Low fuel prices w/ 0-mo. payback							
High fuel prices w/ 24-mo. payback							
75% benefit to buyers							
50% benefit to buyers							
Low SCC							
High SCC							
Very High SCC							
Valuation of CH_4 and N_2O							
5% rebound							
15% rebound							
20% rebound							
RPE-based markup							
ICM-based repair costs							
5^{th} % mass-safety coefficient							
95^{th} % mass-safety coefficient							
No SHEVs							
Wider diesel downsizing							
Lower technology effects							
Higher technology effects							
Lower technology costs							
Higher technology costs							
No changes in fleet mix							

E. Compliance and Flexibility for HD Pickup and Van Standards

(1) Averaging, Banking, and Trading

The Phase 1 program established substantial flexibility in how manufacturers can choose to implement EPA and NHTSA standards while preserving ~~their timely~~the benefits for the environment and for energy consumption and security. Primary among these flexibilities are the gradual phase-in schedule, and the corporate fleet average approach which encompasses averaging, banking and trading described below. ~~Please also~~ See Section IV.A. of the Phase 1 preamble (76 FR 57238) for additional discussion of the Phase 1 averaging, banking, and trading and Section IV.A (3) of the Phase 1 preamble (76 FR 57243) for a discussion of the credit calculation methodology.

Manufacturers in this category typically offer gasoline and diesel versions of HD pickup and van vehicle models. The agencies established chassis-based Phase 1 ~~gasoline and diesel~~ standards that are equivalent in terms of stringency for gasoline and diesel vehicles and are proposing the same approach to stringency for Phase 2. In Phase 1, the agencies established that HD pickups and vans are treated as one large averaging set that includes both gasoline and diesel vehicles[50] and the agencies are proposing to maintain this averaging set approach for Phase 2.

As explained in Section II.C(3) of the Phase 1 preamble (76 FR 57167), and in Section VI.B (3) above, the program ~~contains provisions~~is structured so that~~,~~ final compliance is determined at the end of each model year, when production for the model year is complete~~, a~~. At that point, each manufacturer calculates production-weighted fleet average CO_2 emission and fuel consumption rates along with its production-weighted fleet average ~~CO_2 and fuel consumption~~standard. Under this approach, a manufacturer's HD pickup and van fleet that achieves a fleet average CO_2 or fuel consumption level better than its standard ~~are~~would be allowed to generate credits. Conversely, if the fleet average CO_2 or fuel consumption level does not meet its standard, the fleet would incur debits (also referred to as a shortfall).

A manufacturer whose fleet generates credits in a given model year will have several options for using those credits to offset emissions from other HD pickups and vans. These options include credit carry-back, credit carry-forward, and credit trading within the HD pickup and van averaging set. These types of credit provisions also exist in the light-duty 2012-2016 and 2017-2025 MY vehicle rules, as well as many other mobile source standards issued by EPA under the CAA. The manufacturer will be able to carry back credits to offset a deficit that had accrued in a prior model year and was subsequently carried over to the current model year, with a limitation on the carry-back of credits to three model years. After satisfying any need to offset pre-existing deficits, a manufacturer may bank remaining credits for use in future years, with a limitation on the carry-forward of credits to five model years. Averaging vehicle credits with engine credits or between vehicle weight classes is not allowed, as discussed in Section I.~~C.~~ The agencies are not proposing changes to any of these provisions for the Phase 2 program.

The agencies request comment on the merits of a temporary credit carry-forward period of longer than 5 years for HD pick-ups and vans, allowing Phase 1 credits generated in MYs 2014-2019 to be used through MY 2025. EPA included a similar provision in the MY 2017-2025 light-duty vehicle rule, which allows a one-time credit carry-forward of MY 2010-2015 credits to be carried forward through MY 2021.[51] Such a credit carry-forward extension for HD

[50] See 40 CFR Section 1037.104 (d). Credits may not be transferred or traded between this vehicle averaging set and loose engines or other heavy-duty categories, as discussed in Section I.

[51] 77 FR 62788, October 15, 2012.

pick-ups and vans may provide manufacturers with additional flexibility during the transition to the proposed Phase 2 standards. A temporary credit carry-forward period of longer than five years for Phase 1 credits may help manufacturers resolve lead-time issues they might face as the proposed more stringent Phase 2 standards phase-in and help avoid negative impacts to their product redesign cycles which tend to be longer than those for light-duty vehicles.

As discussed in Section VI.B.4., EPA is proposing to change the HD pickup and van useful life for GHG emissions from the current 11 years/120,000 miles to 15 years/150,000 miles to make the useful life for GHG emissions consistent with the useful life of criteria pollutants recently updated in the Tier 3 rule. As shown in the Equation 1~~Equation 1~~ ~~Equation 1~~ credits calculation formula below, established by the Phase 1 rule, useful life in miles is a multiplicative factor included in the calculation of CO_2 and fuel consumption credits. In order to ensure banked credits maintain their value in the transition from Phase 1 to Phase 2, NHTSA and EPA propose an adjustment factor of 1.25 for credits that are carried forward from Phase 1 to the MY 2021 and later Phase 2 standards. Without this adjustment factor the proposed change in useful life would effectively result in a discount of banked credits that are carried forward from Phase 1 to Phase 2, which is not the intent of the change in the useful life. The agencies do not believe that this proposed adjustment results in a loss of program benefits because there is little or no deterioration anticipated for CO_2 emissions and fuel consumption over the life of the vehicles. Also, as described in the standards and feasibility sections above, the carry-forward of credits is an integral part of the program, helping to smoothing the transition to the new Phase 2 standards. The agencies believe that effectively discounting carry-forward credits from Phase 1 to Phase 2 would be unnecessary and could negatively impact the feasibility of the proposed Phase 2 standards. EPA and NHTSA request comment on all aspects of the averaging, banking, and trading program.

Equation 1~~13~~: Total Model Year Credit (Debit) Calculation

CO_2 Credits (Mg) = [(CO_2 Std – CO_2 Act) × Volume × UL] ÷ 1,000,000

Fuel Consumption Credits (gallons) = (FC Std – FC Act) × Volume × UL × 100

Where:

CO_2 Std = Fleet average CO_2 standard (g/mi)

FC Std = Fleet average fuel consumption standard (gal/100 mile)

CO_2 Act = Fleet average actual CO_2 value (g/mi)

FC Act = Fleet average actual fuel consumption value (gal/100 mile)

Volume = the total production of vehicles in the regulatory category

UL = the useful life for the regulatory category (miles)

(2) Advanced Technology Credits

The Phase 1 program included on an interim basis advanced technology credits for MYs 2014 and later in the form of a multiplier of 1.5 for the following technologies:

- Hybrid powertrain designs that include energy storage systems
- Rankine cycle engines
- All-electric vehicles
- Fuel cell vehicles

The advanced technology credit program is intended to encourage early development of technologies that are not yet commercially available. This multiplier approach means that each advanced technology vehicle would count as 1.5 vehicles in a manufacturer's compliance calculation. A manufacturer also has the option to subtract these vehicles out of its fleet and determine their performance as a separate fleet calculating advanced technology credits that can be used for all other HD vehicle categories, but these credits would, of course, not then be reflected in the manufacturer's conventional pickup and van category credit balance. The credits are thus 'special' in that they can be applied across the entire heavy-duty sector, unlike the ABT and early credits discussed above and the innovative technology credits discussed in the following subsection. The agencies also capped the amount of advanced credits that can be transferred into any averaging set into any model year at 60,000 Mg to prevent market distortions.

The advanced technology multipliers were included on an interim basis in the Phase 1 program and the agencies are proposing to end the incentive multipliers beginning in MY 2021, when the more stringent Phase 2 standards are proposed to begin phase-in. The agencies are proposing a similar approach for the other HD sectors as discussed in Section I.C. (1). The advanced technology incentives are intended to promote the commercialization of technologies that have the potential to provide substantially better GHG emissions and fuel consumption if they were able to overcome major near-term market barriers. However, the incentives are not intended to be a permanent part of the program as they result in a decrease in overall GHG emissions and fuel consumption benefits associated with the program when used. The agencies believe the proposal represents a reasonable balance of these factors. EPA and NHTSA similarly included temporary advanced technology multipliers in the light-duty 2017-2025 program, believing it was worthwhile to forego modest additional emissions reductions and fuel consumption improvements in the near-term in order to lay the foundation for the potential for much larger "game-changing" GHG and oil consumption reductions in the longer term.[52] The incentives in the light-duty vehicle program are available through the 2021 model year.

[52] 77 FR 62811, October 15, 2012.

The agencies request comment on the proposed approach for the advanced technology multipliers for HD pickups and vans, including comments on whether or not the credits should be extended to later model years for more advanced technologies such as EVs and fuel cell vehicles. These technologies would presumably need to overcome the highest hurdles to commercialization for HD pickups and vans, and also have the potential to provide the highest level of benefit.

NHTSA and EPA established that for Phase 1, EVs and other zero tailpipe emission vehicles be factored into the fleet average GHG and fuel consumption calculations based on the diesel standards targets for their model year and work factor. The agencies also established for electric and zero emission vehicles that in the credits equation the actual emissions and fuel consumption performance be set to zero (*i.e.* that emissions be considered on a tailpipe basis exclusively) rather than including upstream emissions or energy consumption associated with electricity generation. Although the agencies are proposing to end advanced technology credits, the agencies are proposing to continue standards based on tailpipe emissions and therefore propose to continue to count electric operation at zero grams per mile.

(3) Innovative Technology (Off-cycle) Credits

The Phase 1 program established an opportunity for manufacturers to generate credits by applying innovative technologies ~~who's~~whose CO_2 and fuel consumption benefits are not captured on the 2-cycle test procedure (i.e., off-cycle).[53] To generate credits, manufacturers are required to submit data and a methodology for determining the level of credits for the innovative technology subject to EPA and NHTSA review and approval. The application for innovative technology credits is also subject to a public evaluation process and comment period. EPA and NHTSA would approve the methodology and credits only if certain criteria were met. Baseline emissions and fuel consumption[54] and control emissions and fuel consumption need to be clearly demonstrated over a wide range of real world driving conditions and over a sufficient number of vehicles to address issues of uncertainty with the data. Data must be on a vehicle model-specific basis unless a manufacturer demonstrated model-specific data were not necessary. Once a complete application is submitted by the manufacturer, the regulations require that the agencies publish a notice of availability in the Federal Register notifying the public of a manufacturer's proposed off-cycle credit calculation methodology and provide opportunity for comment.

The approach finalized for HD pickups and vans paralleled provisions for off-cycle credits in the MY 2012-2016 light-duty vehicle GHG program.[55] In the MY 2017-2025 light-duty vehicle program, EPA revised the off-cycle credits program for light-duty vehicles to streamline the credits process. In addition to the process established in the MY 2012-2016 rule, EPA added a list or "menu" of pre-approved off-cycle technologies and associated credit

[53] See 76 FR 57251, September 15, 2011 and 40 CFR 1037.104(d)(13).
[54] Fuel consumption is derived from measured CO_2 emissions using conversion factors of 8,887 g CO_2/gallon for gasoline and 10,180 g CO_2/gallon for diesel fuel.
[55] See 75 FR 25440, May 7, 2010 and 40 CFR 86.1869(d).

levels.[56] Manufacturers may use the pre-defined off-cycle technology menu to generate light-duty vehicle credits by demonstrating at time of certification that the vehicles are equipped with the technology without providing additional test data. Different levels of credits are provided for cars and light trucks in the light-duty program. NHTSA also included these credits in the CAFE program (in gallons/mile equivalent) starting with MY 2017. The list of pre-approved off-cycle technologies is shown below.

Table VI-28~~25~~: Pre-approved Off-cycle Technologies for Light-duty Vehicles

Pre-approved technologies
High Efficiency Exterior Lighting (at 100W)
Waste Heat Recovery (at 100W; scalable)
Solar Roof Panels (for 75 W, battery charging only)
Solar Roof Panels (for 75 W, active cabin ventilation plus battery charging)
Active Aerodynamic Improvements (scalable)
Engine Idle Start-Stop w/ heater circulation system
Engine Idle Start-Stop without/ heater circulation system
Active Transmission Warm-Up
Active Engine Warm-Up
Solar/Thermal Control

EPA and NHTSA are requesting comment on establishing a pre-defined technology menu list for HD pickups and vans. The list for HD pickups and vans could include some or all of the technologies listed in Table VI-28~~Table VI-25~~ for light-duty vehicles. As with the light-duty program, the pre-defined list may simplify the process for generating off-cycle credits and may further encourage the introduction of these innovative technologies. However, the appropriate level of credits for the heavier vehicles would need to be established. The agencies request comments with supporting HD pickup and van specific data and analysis that would provide a substantive basis for appropriate adjustments to the credits levels for the HD pickup and van category. The data and analysis would need to demonstrate that the pre-defined credit level represents real-world emissions reductions and fuel consumption improvements not captured by the 2-cycle test procedures.

[56] 77 FR 62832-62839, October 15, 2012.

As with the light-duty vehicle program, the agencies would also consider including a cap on credits generated from a pre-defined list established for HD pickups and vans. The cap for the light-duty vehicle program is 10 g/mile (and gallons/mi equivalent) applied on a manufacturer fleet-wide basis.[57] The 10 g/mile cap limits the total off-cycle credits allowed based on the pre-defined list across the manufacturer's light-duty vehicle fleet. The agencies adopted the cap on credits to address issues of uncertainty regarding the level of credits automatically assigned to each technology. Manufacturers able to demonstrate that a technology provides improvements beyond the menu credit level would be able to apply for additional credits through the individual demonstration process noted above. Credits based on the individual manufacturer demonstration would not count against the credit cap. If a menu list of credits is developed to be included in the HD pickup and van program, a cap may also be appropriate depending on the technology list and credit levels. The agencies request comments on all aspects of the off-cycle credits program for HD trucks and vans.

(4) Demonstrating Compliance for Heavy-duty Pickup Trucks and Vans

The Phase 1 rule established a comprehensive compliance program for HD pickups and vans that NHTSA and EPA are generally retaining for Phase 2. The compliance provisions cover details regarding the implementation of the fleet average standards including vehicle certification, demonstrating compliance at the end of the model year, in-use standards and testing, carryover of certification test data, and reporting requirements. Please see Section V.B (1) of the Phase 1 rule preamble (76 FR 57256-57263) for a detailed discussion of these provisions.

The Phase 1 rule contains special provisions regarding loose engines and optional chassis certification of ~~sister~~certain vocational vehicles ~~and loose engines.~~over 14,000 lbs. GVWR. The agencies are proposing to extend the ~~sister vehicle~~optional chassis certification provisions to Phase 2 and are not proposing to extend the loose engine provisions. See the vocational vehicle Section V above for a complete discussion of these proposals.

[57] See 40 CFR 86.1869-12(b).